PROCEEDINGS
OF THE 54TH MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD

4-6 June 1991

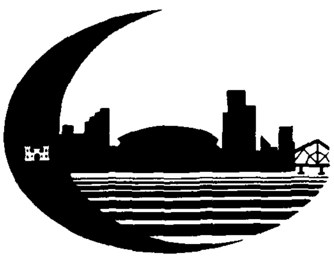
NEW ORLEANS, LOUISIANA

Hosted by

US Army Engineer Division, Lower Mississippi Valley

and

US Army Engineer District, New Orleans



New Orleans, LA
The Crescent City

April 1992

Final Report

Approved For Public Release; Distribution Is Unlimited

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These proceedings provide summaries of the papers presented at the semiannual meeting of the Coastal Engineering Research Board (CERB). Also included are discussions of CERB business, recommendations for research and development by CERB members, and public comment.

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PREFACE

The Proceedings of the 54th Meeting of the Coastal Engineering Research Board (CERB) were prepared for the Office, Chief of Engineers, by the Coastal Engineering Research Center (CERC), of the US Army Engineer Waterways Experiment Station (WES). These proceedings provide a record of the papers presented, the questions and comments in response to them, and the interaction among program participants and the CERB.

The meeting was hosted by the US Army Engineer Division, Lower Mississippi Valley, under the direction of MG Arthur E. Williams, Commander, and the US Army Engineer District, New Orleans (LMN), under the direction of COL Richard V. Gorski, Commander.

Acknowledgements are extended to the following from LMN: Ms. June Holley, who assisted with the coordination of the meeting; Ms. Susan McEnery who assisted with various administrative details; Mr. Donald E. Miller for his photography and visual aids assistance; and Messrs. Ralph J. Marchese and Charles A. Askings for their audio assistance. Thanks are extended to guest participants Dr. Shea Penland, Louisiana State Geological Survey, Baton Rouge, LA; Mr. James B. Edmonson, South Central Planning and Development Commission, Thibodaux, LA; and Ms. Sally S. Davenport, Texas General Land Office, Austin, TX. Thanks are extended to Mrs. Sharon L. Hanks for coordinating and assisting in setting up the meeting and assembling information for this publication; Dr. Fred E. Camfield for preparing the draft proceedings from the transcript; Ms. Janean Shirley and the Information Technology Laboratory for editing these proceedings, all of whom are at WES. Thanks are extended also to Ms. Dale N. Milford, Certi-Comp Court Reporters, Inc., for taking verbatim dictation of the meeting.

The proceedings were reviewed and edited for technical accuracy by Dr. James R. Houston, Chief, CERC, and Mr. Charles C. Calhoun, Jr., Assistant Chief, CERC. COL Larry B. Fulton, Executive Secretary of the board and former Commander and Director, WES, provided additional review.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

Arthur E. Williams

ARTHUR E. WILLIAMS
Major General, US Army
President, Coastal Engineering Research Board

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INTRODUCTION

The 54th Meeting of the Coastal Engineering Research Board (CERB) was held at the Holiday Inn Crowne Plaza in New Orleans, LA, on 4-6 June 1991. It was hosted by the US Army Engineer Division, Lower Mississippi Valley, under the direction or MG Arthur E. Williams, Commander, and the US Army Engineer District, New Orleans, under the direction of COL Richard V. Gorski.

The Beach Erosion Board (BEB), forerunner of the CERB, was formed by the Corps in 1930 to study beach erosion problems. In 1963, Public Law 88-172 dissolved the BEB by establishing the CERB as an advisory board to the Corps and designating a new organization, the Coastal Engineering Research Center (CERC), as the research arm of the Corps. The CERB functions to review programs relating to coastal engineering research and development and to recommend areas for particular emphasis or suggest new topics for study. The Board's four military and three civilian members officially meet twice a year at a particular coastal Corps District or Division to do the following:

a. Disseminate information of general interest to Corps coastal Districts and Divisions.

b. Obtain reports on coastal engineering projects in the host (local) District or Division; receive requests for research needs.

c. Provide an opportunity for state and private institutions and organizations to report on local coastal research needs, coastal studies, and new coastal engineering techniques.

d. Provide a general forum for public inquiry.

e. Provide recommendations for coastal engineering research and development.

Presentations during the 54th CERB meeting dealt with coastal flood protection. Documented in these proceedings are summaries of presentations made at the meeting, discussions which followed the presentations, and recommendations by the Board. A verbatim transcript of the proceedings is on file at CERC, US Army Engineer Waterways Experiment Station.

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54TH COASTAL ENGINEERING RESEARCH BOARD MEETING

New Orleans, LA
4-6 June 1991

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BG Roger F. Yankoupe
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Professor Fredric Raichlen
Professor Robert O. Reid

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Mr. William L. Preslan, CEWES-CD-P
Mr. Thomas W. Richardson, CEWES-CD
Mr. Ernest R. Smith, CEWES-CW-R

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Dr. Edward F. Thompson, CEWES-CR
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Dr. C. Linwood Vincent, CEWES-CV-CH

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Mr. James B. Edmonson, South Central Planning and Development Commission, Thibodaux, LA
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Dr. Shea Penland, Louisiana State Geological Survey, Baton Rouge, LA
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54TH COASTAL ENGINEERING RESEARCH BOARD MEETING

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COURT REPORTER

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54TH COASTAL ENGINEERING RESEARCH BOARD MEETING
4-6 June 1991
New Orleans, LA

AGENDA

THEME: Coastal Flood Protection

TUESDAY, 4 June

0700 - 0815	Registration	
0815 - 0820	Opening Remarks	MG Arthur E. Williams
0820 - 0825	Welcome to Lower Mississippi Valley Division	MG Arthur E. Williams, LMVD
0825 - 0835	Welcome to New Orleans District	COL Richard V. Gorski, LMN
0835 - 0905	Review of CERB Business	COL Larry B. Fulton, WES
0905 - 0915	National Berm Demonstration Program	Dr. Susan Ivester Rees, SAM
0915 - 1100	Dredging Research Program	
0915-0930	Update of DRP	Mr. E. C. McNair, Jr., CERC/WES
0930-1000	DRP Monitoring of Dredged Material Plumes (Includes video entitled "Plume Tracking off Mobile, Alabama")	Dr. Nicholas C. Kraus, CERC/WES
1000-1015	Break	
1015-1030	Plume Monitoring Experience at the Miami Harbor Project	Mr. Mark P. Skarbek, SAJ
1030-1045	Discharged Dredged Material Plume Monitoring	Dr. John R. Proni, AOML/NOAA
1045-1100	Questions from Board	
1100 - 1145	Wetlands Research Program Overview/ Coastal Initiative	Mr. Russell F. Theriot, EL/WES Ms. Joan Pope, CERC/WES
1145 - 1215	Oil Spill Update	Mr. E. C. McNair, Jr. CERC/WES

1215 - 1330	Lunch	
1330 - 1700	Panel - Coastal Flooding/Erosion - Gulf Coast Perspective and Initiatives	
1330-1350	Gulf of Mexico Program - Coastal and Shoreline Erosion Subcommittee - The Magnitude of the Problem	Mr. Thomas R. Campbell, LMVD
1350-1410	Coastal Erosion and Wetlands Loss in Louisiana Status of US Geological Survey Coastal Research Activities	Mr. S. Jeffress Williams, US Geological Survey
1410-1430	Non-Fuel Mineral Resource Activities of the EEZ Gulf of Mexico Task Force	Mr. T. John Rowland, Minerals Management Service
1430-1450	Coastal Land Loss in Louisiana - Status of the Louisiana Geological Survey Research Activities	Dr. Shea Penland, Louisiana State Geological Survey
1450-1510	Erosion, Flooding, and Planning in the Coastal Parishes of Louisiana	Mr. James B. Edmonson, South Central Planning and Development Commission
1510-1530	Break	
1530-1550	Coastal Erosion in Texas	Ms. Sally S. Davenport, Texas General Land Office
1550-1610	Corps O&M Activities and Programs to Reduce Coastal Erosion	Dr. Linda L. Glenboski, LMN
1610-1630	Corps Studies Under Way that Address Coastal and Shoreline Erosion	Mr. Robert H. Schroeder, LMN
1630-1700	Discussion	
1700	Recess for Day	
1830 - 2100	Social (Cajun Dinner - Casual Attire)	

WEDNESDAY, 5 June

0800 - 0815	Opening Remarks	MG Arthur E. Williams
0815 - 0830	Chief's Charge to the CERB	MG Arthur E. Williams
0830 - 1120	Waves and Storm Surge Due to Hurricanes	
0830-0840	Introduction - Corps Uses of Hurricane Information	Dr. C. Linwood Vincent, CERC/WES
0840-0900	Research Needs: Hurricane Surge and Waves in New Orleans District	Mr. A. J. Combe, LMN
0900-0920	Break	
0920-1040	Corps of Engineers Procedures and State of the Art in Modeling Hurricane Effects	
	Wind Prediction	Dr. E. F. Thompson, CERC
	Storm Surge Water Levels	Mr. H. L. Butler, CERC
	Wave Prediction	Dr. M. C. Miller, CERC
	Beach Modification	Dr. N. C. Kraus, CERC
1040-1055	Summary of Capabilities and Research Requirements	Dr. C. Linwood Vincent, CERC/WES
1055-1120	Discussion and Questions from CERB	
1120 - 1230	Lunch	
1230 - 1500	Coastal Flooding Emergencies	
1230-1250	Introduction - Corps Authority/Role in Disaster Response	Mr. Gary M. Campbell, HQUSACE
1250-1310	FEMA Authority/Role in Disaster Response	Mr. Robert P. Fletcher, FEMA
1310-1340	R&D Needs Identified from Hurricane Hugo and other Disasters	Mr. T. W. Richardson, CERC/WES
1340-1400	Break	

1400-1415	Ongoing Research and Development Efforts	Mr. Frank E. Stubbs, LMVD
1415-1435	Potential R&D Needs	Mr. Gary M. Campbell, HQUSACE
1435-1500	Discussion and Questions from CERB	
1500 -	Recess for Day (Board in Executive Session)	

THURSDAY, 6 June

0900 - 0915	Opening Remarks	MG Arthur E. Williams
0915 - 0945	Public Comment	
0945 - 1100	Board Response to Chief's Charge	CERB
1100	Adjourn	

OPENING REMARKS
AND
WELCOME TO LOWER MISSISSIPPI VALLEY DIVISION
AND NEW ORLEANS DISTRICT

MG Arthur E. Williams opened the 54th Meeting of the Coastal Engineering Research Board. He indicated that in addition to being Commander of the Lower Mississippi Valley Division, he was Acting Director of Civil Works and Acting President of the Board while MG Patrick J. Kelly was serving as the representative for the Secretary of Defense in charge of reconstruction efforts in Kuwait. He welcomed back continuing members of the Board, Professors Robert O. Reid from Texas A&M University, Robert A. Dalrymple from the University of Delaware, and Fredric Raichlen from the California Institute of Technology. He also welcomed a new member, BG Stanley G. Genega, Commander, Southwestern Division. MG Williams indicated that a second new Board member, BG Roger F. Yankoupe, Commander, South Pacific Division, would join the meeting later. A third new member, MG John F. Sobke, Commander of the South Atlantic Division, was unable to attend.

MG Williams welcomed attendees to the Lower Mississippi Valley Division. He indicated that the Division extends from Hannibal, MO, to the Gulf of Mexico and has primary missions of navigation and flood control. The Division operates several locks and dams, and several reservoirs and, in that respect, gets involved with recreation and hydropower. They also have a mission that involves the environment. The Division has about 6,000 civilian employees and 20 military officers assigned to four Districts and the Division Headquarters. The Districts are located in St. Louis, Memphis, Vicksburg, and New Orleans. The annual budget is about $850 million.

MG Williams said that the Corps of Engineers had an ongoing study for reorganization. The Department of Defense Base Realignment and Closure (BRAC) Commission had elected to look at the proposed reorganization for the purpose of including it in the overall BRAC Plan. He then turned the floor over to COL Richard V. Gorski, Commander, New Orleans District.

COL Gorski welcomed the attendees to New Orleans and introduced members of his staff who were assisting with the meeting. He noted that Louisiana has 40 percent of the Nation's coastal wetlands, and accounts for 80 percent of the loss of coastal wetlands. Louisiana is losing coastal wetlands at the rate of 31 square miles per year.

The Chandeleur Islands are a chain of islands that are part of an old lobe of the Mississippi delta. Those islands are now rapidly eroding away. That is happening all along the coast of Louisiana. The barrier islands are what protects Louisiana's coastal wetlands from erosion. There is also differential erosion where navigation channels come out into the Gulf of Mexico.

There is rapid erosion in places like Holly Beach. Camps that people have built on the coastline for recreation are being lost. Eroding coastlines expose facilities to the effects of storms.

Louisiana is home to more than two thirds of the migratory waterfowl that use the Mississippi flyway. There is an enormous collection of different kinds of bird species, including the bald eagle. Louisiana is third in the nation, behind Alaska and Florida, in nesting pairs of bald eagles. Louisiana has the largest percentage of commercial fisheries in the nation and leads the nation in landings of commercial fish and in shrimp harvested. All of these resources are threatened by the loss of coastal wetlands.

Wetlands are lost not only to Mother Nature, but also to the forces of man. Canals have been dug for oil and gas exploration, and navigation channels have been constructed and maintained. Ship waves generated by traffic in the navigation channels erode the wetlands bordering the channels.

There is a demand to use material dredged from navigation channels for the creation of wetlands. The 50 to 90 million cu yd of material dredged annually could create 6,000 acres of wetlands. There are some technical and economic problems in doing that.

COL Gorski said there have been some successes. Queen Bess Island is an example. That was a cooperative effort between the New Orleans District, the state of Louisiana, and Jefferson Parish. Material from the Barataria Bay dredging program was moved a mile and a half to fill in the area around that island. This improved a nesting area for the brown pelican, an endangered species. That environmental enhancement added $400,000 to the cost of an $800,000 project, i.e., it added 50 percent to the project cost.

In the Mississippi River's Southwest Pass, the Corps routinely uses dredged material to build new vegetated wetlands. This is relatively easy, as the dredged material is simply pumped over the protected banks. That is what the Corps would like to be able to do throughout Louisiana. They need help in overcoming the technical problems and coming up with means of paying for the projects.

Congress passed the Coastal Wetlands Planning, Protection, and Restoration Act in 1990. This gives $35 million per year to the state of Louisiana over a period of 5 years. Expenditures will be directed by a task force consisting of five Federal agencies and the state of Louisiana. The New Orleans District Engineer is the chairman of the task force. Other Federal agencies are the Environmental Protection Agency, Department of Interior, Department of Commerce, and Department of Agriculture. The money will be expended for restoring, protecting, and preserving coastal wetlands in Louisiana.

REVIEW OF COASTAL ENGINEERING RESEARCH BOARD BUSINESS

COL Larry B. Fulton, Executive Secretary
Coastal Engineering Research Board
Commander and Director
US Army Engineer Waterways Experiment Station
Vicksburg, MS

There were several action items resulting from the last Board meeting in Fort Lauderdale, FL. The list at Appendix B covers the status of action items from the Fort Lauderdale meeting and continuing action items from previous Board meetings. All other action items have been completed. We will continue to update the status of action items prior to each meeting, and provide a list to the Board as read-ahead material. At the 47th meeting of the Coastal Engineering Research Board (CERB) in Corpus Christi, TX, we were asked to formalize the action item list. A master list showing actions taken since the 47th meeting is maintained at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station.

I will now cover the status of action items shown at Appendix B. Item 53-1 directed us to take necessary action to have "Coastal Engineer" added to the Federal personnel classification system. Our investigations have indicated that there is no particular problem in doing this under the GS-810 Civil Engineer series. This would be similar to other specialty classifications such as Hydraulic Engineer, which are presently under this series. It is necessary to justify the need to the Office of Personnel Management, and our Human Resources Office has prepared a justification based on input provided by CERC. A memorandum was sent forward through the Human Resources Office, Headquarters, US Army Corps of Engineers (USACE) on 11 April 1991 for transmittal to the Office of Personnel Management.

Item 53-2 directed us to develop a method for collecting and distributing information learned by Districts from their experiences with constructing coastal projects. We found that methods for collecting information learned from experiences with constructing coastal projects already existed and are provided for in existing regulations. The weak link seems to be in the distribution of the information.

The CERC presently organizes Corps Coastal Workshops on an annual basis. These are directed toward Corps-wide coastal issues in even-numbered years, and regional issues in odd-numbered years. The CERC will initiate project construction review sessions in these workshops. Field engineers will be invited to make presentations on the design and construction of coastal projects in their Districts, and highlight "lessons learned." This will provide good training for young engineers, and summary proceedings of the workshops are published and distributed Corps-wide. Lessons learned in coastal construction also will be presented, when appropriate, in Coastal Engineering Technical Notes.

Item 53-3 directed us to include a session on structure rehabilitation at the theme meeting on Coastal Structures in June 1992 to be hosted by the North Pacific Division and the Portland District. That session will be included.

Item 53-4 relates to a report on the Corps' new Wetlands Research Program, which will be given later in this meeting.

Item 53-5 directed us to have a status report on the Field Wave Gaging Program and results from the Monitoring Completed Coastal Projects Program at a future meeting. That is tentatively scheduled for the meeting in the North Atlantic Division in October 1992 where the theme will be Coastal Data Collection.

Item 53-6 was to invite appropriate representatives from other agencies involved with mapping sand resources to this meeting. Representatives of those agencies are on this afternoon's agenda.

Item 53-7 was to determine the feasibility of conducting a major Operations and Maintenance funded research program on inlets. Jesse Pfeiffer of the Headquarter's Directorate of Research and Development (DRD) discussed the feasibility of a program with Don Cluff, at that time Chief, Programs Division, and John Elmore, Chief, Operations and Readiness Division, in Corps Headquarters. Both Mr. Cluff and Mr. Elmore supported, in principle, the concept of a Coastal Inlets Research Program and agreed it would be worthwhile to conduct a workshop to determine field needs. A workshop was held in early February with attendance by about 30 District, Division, and Headquarters personnel. District and Division personnel presented over 70 problems their offices were experiencing in Corps activities relating to inlets, and by the end of the meeting prioritized these problems. Staff at CERC consolidated these into 31 identified problems, developing a conceptual research program based on these needs, and briefed Mr. Elmore, his deputy, Jim Crews, and Barry Holliday, Chief of the Dredging Branch, on the program in mid-May. A detailed technical program will be developed this summer by CERC with participation by the civilian Board members and other experts. The DRD has requested that CERC provide input for a proposed program starting in FY93.

Item 53-8 was to provide briefings on elements of the Dredging Research Program at each Board meeting. Presentations are included in the agenda for this meeting, and will be included at future Board meetings.

Item 53-9 directed us to provide comparative data on costs of various sand-bypassing systems at this meeting. These data have been prepared and are located in Appendix C.

Item 53-10 was to determine roles of the Federal Emergency Management Agency (FEMA), the Corps, and other Federal agencies in collecting post-storm data and to recommend how coordination between these agencies can be improved to provide a complete and consistent data set. This item will be covered tomorrow afternoon by a panel on Coastal Flooding Emergencies, which will include presentations by the Corps of Engineers and FEMA.

Action Item 53-11 asked that copies of the draft National Economic Development manual be provided to civilian members of the CERB for their review. Copies of the draft manual are being provided to members of the Board at this meeting, and we welcome their comments so that they might be considered for the final version of the manual.

Older items on which action is continuing include ...

Action Item 50-3 related to an initiative to seek funds for universities to conduct basic research in coastal engineering. Dr. Robert Oswald, Director of Research and Development, Headquarters, USACE, worked with CERC and was able to convince the Army Research Office to fund a small grant program. The Program was announced recently as a part of the Department of Defense University Research Initiative. The university or university consortium that successfully obtains the grant will receive about $400,000 per year for up to 5 years to perform basic research in coastal processes. Therefore, this successful initiative by the Board will result in about $2 million for university basic research into coastal processes.

On other items of interest ...

I reported at the last Board meeting on our continued progress on the Education Initiative from the Board's meeting in Sausalito, CA. To refresh your memory, the Coastal Engineering Education Program (CEEP), or as many call it, CERC U., is a 1-year program offered by CERC and Texas A&M University through the WES Graduate Institute. Students successfully completing the program will earn a Master of Engineering degree from Texas A&M. We had six coastal specialists from Corps field offices selected for the first session of the CEEP that started last August. They have completed two semesters at Texas A&M and the 3-week Coastal Field Methods course at CERC's Field Research Facility in Duck, NC. That course was taught by Dr. Thomas White of CERC. There were eight other Corps coastal specialists enrolled in the Field Methods course. The six CEEP students started the summer session at CERC this week, where Dr. Nicholas Kraus is teaching the Sediment Processes course and Dr. Steven Hughes the physical modeling course. While at CERC, they will also complete their Special Problems under the direction of Drs. White, Kraus, Hughes, and Edward Thompson. They will complete the program this August.

We have had continued progress on the Automated Coastal Engineering Systems, which has been discussed at previous Board meetings. Version 1.05 was released to the public earlier this year. Version 1.06 has been released to the Corps, and this new version significantly enhances the system's capabilities.

The CERC also has created a Bulletin Board called COASTAL SHAREWARE from which users can download some computer programs developed at CERC. Access is from any personal computer having a modem. Users will have limited access until their security code is increased by the system operator at which time they will be able to download the programs.

Finally, Mr. William Murden, formerly Chief of the Corps Dredging Division, made a presentation at the Board's meeting in Corpus Christi, TX, in May 1987 and outlined the concept of placing dredged material in such a manner that "berms" are created. The Corps is in the last stages of the National Berm Demonstration Program being conducted in and supported by the Mobile

District. This program will be reported in detail at our next Board meeting where the theme will be dredging. Results from the program have been extremely exciting, and we will call on the Mobile District to present a preliminary report.

NATIONAL BERM DEMONSTRATION PROGRAM

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The subject of berm construction and the National Berm Demonstration Project at Mobile have been reported to the Coastal Engineering Research Board on a number of occasions beginning in 1985 when Mr. William Murden, former Chief, Dredging Division, Water Resources Support Center, discussed options for dredged material placement and the positive results from an earlier pilot study off Virginia Beach by the Norfolk District.

LTG H. J. Hatch, then Director of Civil Works, approved a national demonstration project to assess and document potential physical and fishery benefits associated with underwater berms as a beneficial use application of dredged material. While a number of locations throughout the country were considered for the demonstration project, the Mobile District (SAM) proposed incorporation of the concept of berm construction into the maintenance and deepening of Mobile Harbor and was able to quickly gain the support of the sponsor and the environmental community for the project.

A steering committee was formed representing SAM, the Coastal Engineering Research Center (CERC) and the Environmental Lab (EL) at the US Army Engineer Waterways Experiment Station, the South Atlantic Division, and the Headquarters offices of the Operations, Construction, and Readiness Division (formerly Dredging Division, Water Resources Support Center), Planning and Policy Division, and the Directorate of Research and Development. The committee met regularly during the course of the demonstration project to oversee the progress of the program by evaluating the ongoing results with the principal investigators and determining program modifications as appropriate, as well as to determine the means for disseminating the information.

In early 1987, SAM constructed a "feeder" berm in relatively shallow water, and in February 1988 began construction of a "stable" berm in deeper water in the Gulf of Mexico south of Dauphin Island.

The feeder berm was constructed with maintenance material from routine hopper dredging of the entrance channel from the gulf into Mobile Bay. Historically, material from this area was transported to the gulf site, approximately 5 miles offshore, for disposal. The objective of the feeder berm was to place sandy dredged material into the active littoral zone and thereby supplement the sand budget of Sand and Dauphin Islands. The placement site is on the west of the Ship Channel about 1 mile southeast of Sand Island, and about 4 miles from Dauphin Island. Approximately 460,000 cu yd of material was placed in 18-19 ft of water by shallow-draft split hull hopper dredges during construction of the 1-mile-long, 6-ft-high structure. A cooperative monitoring program was developed by SAM and CERC to investigate the movement of material from the berm. This program included bathymetric surveys, collection of wave information, and deployment of seabed drifters to track bottom currents. Since the haul distance to the "feeder" location was about the same as to the historical disposal site, construction of the berm was at no extra cost. Extensive monitoring has been conducted over a 4-year period including wave gage equipment and instrumentation provided under the Dredging Research Program (DRP).

The objective of the feeder berm monitoring was to determine whether the placed material became incorporated into the active transport system. Results of 4 years of monitoring indicate a gradual movement of sand westward and toward shore. The highest percentage of seabed drifters have been retrieved on Dauphin Island, indicating favorable conditions for movement of sand toward the barrier island.

The stable berm was constructed during the Mobile Harbor, Phase I, Deepening, and is composed of a variety of dredged materials. The bay channel contained primarily soft plastic clays and silts, whereas the bar channel was a mixture of sands and marine clays. The berm, which is the largest underwater feature ever constructed, is located in 40-45 ft of water approximately 3.5 and 5 miles south of Sand and Dauphin Islands, respectively. The 20-ft-high structure was constructed by specifying a 1,000- by 9,000-ft placement zone. Approximately 17 million cu yd were placed in this area creating a feature 1 mile wide at the base and approximately 2.5 miles long. Construction took approximately 2 years and 3 months, and was performed by mechanical dredging equipment in the bay and by hopper dredging in the entrance channel. The deepening and associated construction of the stable berm was funded through the Construction General Program at a cost of $36.3 million. Some savings in construction cost were realized since the dredged material was all placed in an elevated configuration within the designated placement area closest to the channel. The alternative would have been to place the material in thinner lifts, i.e., 5 ft thick, over a much larger area, which would have resulted in increased transportation costs. The Alabama State Docks, local sponsor, shared in all construction and monitoring costs under the Construction General Program.

Monitoring purposes of the stable berm were threefold: (a) determine whether the feature remains stable; (b) assess how much the berm contributes to wave energy dissipation; and (c) determine whether the berm provides an improved fisheries habitat. The Environmental Protection Agency, Region IV, the SAM, CERC, and EL participated in the initial design of the program. As the monitoring program developed, additional participants included the National Oceanographic and Atmospheric Administration National Marine Fisheries Service, Mississippi Labs, and Mississippi-Alabama Sea Grant.

Because of the length of time required to construct the entire stable berm, monitoring was conducted on a test section. This section, which represented the easternmost 1-mile section of the structure, was completed in August 1988, 6 months after initiation of construction, and contained approximately 4 million cu yd. After completion of this segment, construction activities were shifted to the westernmost end of the structure and placement proceeded in an easterly direction until the two segments of the berm were joined. The stable berm construction was completed in May 1990.

Monitoring of the stable berm included: bathymetric, subbottom profile and side scan surveys, sediment analyses, wave, wind, and barometric pressure data collection, benthic macrofauna and vertical sediment profiling surveys, and fisheries investigations. The fishery investigations included both traditional trawling surveys, feeding analyses, and hydroacoustic surveys.

Baseline surveys were conducted prior to construction in October 1987. The first monitoring survey was conducted in August 1988. Various aspects of the monitoring program have occurred either quarterly or semiannually between August 1988 and March 1991. Results of these studies indicate that:

a. The berm was constructed to the specifications defined in the Plans and Specifications.

b. The berm, although constructed with varying quality of material, has remained stable since initial consolidation.

c. The berm is serving to reduce long period wave (i.e., storm waves) energy. Preliminary data analyses show a reduction of as much as 70 percent of the wave energy from the gulf to the landward side of the berm.

d. The construction and presence of the berm has had no adverse impact on the biological resources of the area. Macroinfaunal communities are similar to those in existence prior to the construction of the berm and fishery resources are similar to those defined by historic surveys.

e. The berm appears to be serving as a fish attractant; however, it is too early to draw definite conclusions. Recent analyses indicate that the berm is serving as a refuge and feeding location for very young juvenile red snapper. Additional surveys will be required to substantiate these benefits.

Although the main monitoring program is complete, monitoring of certain aspects of the berm will continue in the future. The fishery monitoring program will be continued for an indefinite period, depending upon the results attained in later years. Annual bathymetric surveys of both berm structures will also be performed. This additional information will prove valuable in the design and environmental coordination of other berms. Results of these programs should have nationwide application. In addition to the potential physical and fishery benefits that might accrue, application of the concept could result in significant cost savings by reducing haul distances for future new work and maintenance projects.

Other Corps programs have taken advantage of the construction of the stable berm including the DRP. The DRP Task Area One utilized the Mobile berm placement operations during plume tracking activities in calendar year 89, and information from the National Demonstration monitoring has served as a basis for DRP ocean disposal predictive methods.

Since the National Demonstration began, the Corps has constructed successful berms in a number of other locations, including Texas, New York, and California. In all cases, information and experience derived from the

National Demonstration were integral parts of the planning and implementation of these features.

In summary, the authors believe that the National Demonstration has achieved its objectives and has served as an excellent foundation for the Corps' continued efforts to develop beneficial uses of dredged material.

DISCUSSION

Dr. Linda L. Glenboski said that the New Orleans District is getting a lot of pressure to build berms with the dredged material from its ocean disposal sites. She was concerned about possible cost differences, and asked about the distance between the Mobile channel and their ocean disposal site, as compared to the distance to the berm.

Dr. Rees noted that the stable berm was constructed within the ocean disposal site. The feeder berm is in a site cleared through the Clean Water Act, and is closer to the actual dredging location than the ocean disposal site where they had historically placed material. The Mobile District thinks the cost savings resulted from being able to use a much smaller area of the ocean disposal site than an alternative which would have required a thinner layer of material spread over a larger area.

PANEL
DREDGING RESEARCH PROGRAM

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UPDATE OF DREDGING RESEARCH PROGRAM

E. Clark McNair, Jr.

The Dredging Research Program (DRP) is at the halfway point in its life in terms of time and funding. From its beginning, the emphasis of the program has been on developing products for the Major Subordinate Commands and District Commands to use in accomplishing their new construction and maintenance dredging missions. Innovative research has been a factor in this emphasis, but adaptations of existing technology have also played a role. The DRP has been very successful in maintaining the emphasis of product development and, as a maturing program, is now performing technology transfer to Corps of Engineer users. Cost savings associated with product implementation are presently being identified.

The DRP is logically subdivided into five technical areas, each containing a number of associated work units and under the technical direction of a highly capable technical manager. Perhaps the most interesting and challenging of the five areas is Technical Area No. 1, "Analysis of Dredged Material Placed in Open Waters." The work on plume monitoring that will be discussed in later presentations was performed under this technical area. Also underway in Technical Area No. 1 are investigations of boundary layer phenomena, measurement of entrainment and transport of dredged materials placed on sea or lake bottoms, identification and definition of cohesive sediment processes, numerical simulation of the short-term fate of dredged materials released into open waters, numerical simulation of the long-term fate of dredged materials placed in open waters, and techniques for monitoring and confirming behavior of dredged material deposits in open water.

The work and accomplishments of the other DRP technical areas will be the subjects of presentations at later meetings of the Coastal Engineering Research Board.

DISCUSSION

Prof. Raichlen asked what effort is being made in the DRP to look at the chemical and biological aspects of dredged material. Mr. McNair said this was not covered in the DRP, but was being coordinated with other programs that cover that aspect of dredging. The Environmental Laboratory at the US Army Engineer Waterways Experiment Station is studying the chemical and biological aspects, the contaminant release, and the elutriate tests that indicate the tendency of various types of soils to release contaminants. He said environmental enhancement under the DRP comes from physical approaches, including capping and the creation of berms.

DRP MONITORING OF DREDGED MATERIAL PLUMES

Dr. Nicholas C. Kraus

Dredged material placement constitutes a major anthropogenic discharge to the nation's ocean and lake waters. As such, management of dredged material placement sites requires understanding of the movement of this material, both in the water column immediately after discharge and after the sediments arrive at the bottom. Technical Area 1 (TA1) of the Dredging Research Program (DRP) for which the author serves as Technical Manager, is producing monitoring instrumentation and predictive tools in the form of numerical simulation models to serve as a means for managing placement sites in an environmentally sound manner. This presentation will focus on an instrument under development by TA1 that will provide the capability to monitor suspended sediment concentrations at dredged material placement sites as well as at the scene of dredging activities themselves.

The instrument, called PLUMES for PLUme MEasurement System, is centered around Acoustic-Doppler Current Profiler (ADCP) technology that has been commercially available and used in oceanographic applications for several years. The ADCP instruments were originally designed to measure the three-dimensional current field by the Doppler principle applied to transmitted and received acoustic waves. Some type of particulate matter is required to be present in the water medium to reflect the acoustic beams. In addition to the frequency shift, the backscatter intensity from the particles can also be obtained. A fundamental premise of the PLUMES development is that backscatter intensity or amplitude can be related to the sediment concentration in the sample space. The development of PLUMES is proceeding in four phases:

a. Field proof of concept.

b. System design and construction.

c. Laboratory calibration.

d. Field shakedown of turn-key PLUMES. "Turn-key" means a complete stand-alone hardware and software system plus training manuals for routine deployment by Corps of Engineers District personnel without need of specialist researchers.

Phase 1 was completed with successful field monitoring conducted at dredged material placement sites off Mobile, AL, in the summer of 1989 and off

Miami, FL, in April and May 1990. These projects were performed in cooperation with the Ocean Acoustics Division (Dr. John R. Proni, Director) of the Atlantic Oceanographic and Meteorological Laboratories (AOML), National Oceanic and Atmospheric Administration (NOAA). Dr. Proni and his group have been leaders in the use of acoustic instrumentation and the measurement of particulate matter in the ocean. A summary of NOAA and Corps of Engineers cooperation on acoustic instrumentation development and testing, which started in the mid-1970s, will be presented by Dr. Proni at the same session of this meeting. Similarly, a summary of the 1990 dredged material plume monitoring project field trial off Miami Harbor, which provided valuable data for the US Army Engineer District, Jacksonville (SAJ), will be presented by Mr. Mark Skarbek of SAJ. The SAJ is cooperating with DRP TA1 in developing the first turn-key PLUMES, and a field effort with the new system, discussed below, will be performed at an SAJ placement site this autumn.

Phase 2, design and construction, is complete with regard to hardware and a new five-beam configuration. Also, the system implements a broad-band ADCP (BB-ADCP) that transmits a wide range of frequencies, as opposed to the previous standard ADCP that might be called a narrow-band ADCP. Advantages of the BB-ADCP are increased resolution for both the current and backscatter amplitude as well as greater range in the water column. The first BB-ADCP has a central frequency of 600 kHz and a design current resolution in the vertical of 40 to 60 cm, with an amplitude resolution of 5 cm. Software development will be ongoing throughout the life of the DRP until release of the turn-key system. The overall PLUMES development is being reviewed by a four-person committee chaired by the author, with members active in acoustic instrumentation and use in the ocean: Dr. Keith Bedford, Ohio State University; Dr. Proni, NOAA; and Dr. Paul R. Ogushwitz, private consultant.

Phase 3, laboratory calibration, will commence this summer at the SUPERTANK laboratory data collection project to be conducted at Oregon State University (OSU) in July and August of this year. The SUPERTANK project is a cooperative effort involving researchers in both the DRP and the Coastal Program at the Coastal Engineering Research Center (CERC) as well as researchers from several universities and private companies. An approximately 250-ft-long sandy beach will be installed in the 342-ft-long wave tank at OSU. The BB-ADCP tests will take place seaward of the breaker line. In fiscal year 1992, a major laboratory calibration program will commence in cooperation with NOAA using an existing facility at AOML in Miami, FL.

Phase 4, the turn-key PLUMES, is progressing through software and hardware development as well as in continued field deployments. In addition to the aforementioned cooperative project with SAJ, this autumn will see deployments of PLUMES with the Norfolk District to monitor dredged material placement near a sensitive oyster seeding ground in the James River of the Chesapeake Bay Estuary. Also, the Western Division of the Naval Facilities Engineering Command (NAVFAC) has requested that the US Army Engineer Waterways Experiment Station conduct dredged material plume monitoring at a deepwater (2,000 to 6,000 ft) placement site proposed by the Navy off San Francisco. This cooperative project with NAVFAC will allow valuable data to be collected at deepwater sites that would otherwise be unattainable with the limited resources of the DRP. The results will be of fundamental importance to Corps of Engineers projects such as those at California, Hawaii, and Puerto Rico that involve deepwater placement of dredged material.

In conclusion, the PLUMES represents a new class of instrument that will allow reliable monitoring of suspended sediment plumes or, more generally, suspended sediment concentration, at any location in the sea or lakes that is not influenced by air bubbles. The PLUMES will have broad application at dredging and dredged-material placement sites, and in any environment, including rivers, where suspended particulate matter is a concern.

DISCUSSION

Dr. Clifford Truitt said that state regulatory agencies control water quality in terms of Nephelometer Transmission Units (NTU's). The typical standard is something like 29 NTU's above background. He asked where the program was in terms of meeting the state resource regulations. Dr. Kraus noted that the plume measurement system includes all the standard instruments that can be deployed and that are required in all monitoring. He said that this technology is now leading the regulations. The regulations and guidelines may be changing as the equipment proves itself.

Prof. Dalrymple asked about the PLUMES Measurements Systems Committee, the role of the committee, and the responsibilities of each of the committee members as far as guidance. Dr. Kraus said that he views it as a guidance committee, but if problems arise, the committee could change the program of development. He noted that this is a half million dollar project over 3 or

4 years, and will develop what will become a commercially available system. He wanted to have the best minds in the nation, both from circuitry to use and scientific knowledge of the system, to give the DRP guidance on the development and evaluation of the system.

The guidance can be divided into three parts. One is the internal workings of the system itself, the signal processing and modeling of the acoustic beams. Dr. Ogushwitz of Bell Laboratories, Dr. Bedford from Ohio State University, and NOAA provide the expertise there. The second part is calibration, and that will be done cooperatively between Dr. Proni's laboratory and WES. Other people will be brought into the committee as necessary. The third part is the operational deployment. Mr. Barry W. Holliday, Headquarters, US Army Corps of Engineers, Dr. Proni, and Dr. Kraus will be overseeing that part.

The DRP is finite lived. It is necessary to move quickly, and if the committee sees problems, the program needs to be reoriented instantaneously so that those problems can be addressed. Dr. Kraus said if the Coastal Engineering Research Board recommends adding more people to the committee, he would be open to that. He also noted that there would be discussions on cooperative ventures between the Corps, NOAA, and the Environmental Protection Agency, and the scientific aspects of this problem.

PLUME MONITORING EXPERIENCE AT THE MIAMI HARBOR PROJECT

Mark P. Skarbek

The US Army Engineer District, Jacksonville (SAJ), encompassing primarily the Florida Peninsula, has the responsibility for maintaining Federal navigation projects in an environment consisting of some of the most sensitive marine ecosystems found anywhere in the world. This presents SAJ with the problem of executing dredging projects in a timely and economical manner, while adhering to very restrictive environmental rules and regulations. This balance between economics and environment became evident during the Miami Harbor maintenance dredging operation.

Miami Harbor is located in south Florida and was initially constructed during the early 1900's. The 5.7-mile-long entrance channel and the 1,650-ft by 1,700-ft turning basin that make up the majority of the project were blasted out of the coral rock indigenous to the area. Because the project was constructed through hard rock, maintenance dredging has historically been conducted on an approximately 10-year cycle. However, as for any dredged area, the channel and turning basin act as a sink for sediments transported by the tides and currents. The material collecting in the Miami Harbor turning basin consists of a very fine silt and clay that go into suspension very quickly if disturbed. This material had been previously tested and subsequently approved by the Environmental Protection Agency for disposal offshore. The interim Offshore Dredged Material Disposal Site (ODMDS) is located on the western edge of the Gulf Stream, approximately 3.5 nautical miles off the entrance of Miami Harbor, in water depths ranging from 350 to 800 ft.

The Florida Department of Environmental Regulation (DER) and the Florida Department of Natural Resources (DNR) are the state agencies responsible for safeguarding Florida's natural resources. Their concerns are primarily for the environment; in particular, water quality, protection of endangered species, and coastal protection. Suspended sediments and their effect, through turbidity, on nearby coral reefs became primary concerns of state and local environmental agencies during the Miami Harbor maintenance dredging.

The environmental concerns were initially addressed in a numerical modeling study conducted for the SAJ by the Coastal Engineering Research Center (CERC) at the US Army Engineer Waterways Experiment Station (WES). The numerical model simulates the convective descent and dynamic collapse of the sediment plume on the ocean bottom and can be used to determine whether local bottom currents are of sufficient magnitude to erode and transport mounted, placed material. Because the primary concern was the coral reefs located shoreward of the disposal site, the substantial existing current data were used to define a maximum reef-directed velocity vector for the model as a worst-case scenario. Predictions of the simulation model indicated that material reaching the bottom would remain at the site, and any plume would be dispersed before it could reach the reef.

Questions were raised by DNR and DER as to the accuracy of the model. Because of these concerns, a field study was conducted to investigate the dispersion characteristics of the interim disposal site. The main objective of the field study was to identify and monitor the environmentally significant physical processes at the ODMDS to determine the accuracy of the previously performed numerical modeling. The field investigation was conducted by SAJ, CERC, and the Atlantic Oceanographic and Meteorological Laboratories of the National Oceanic and Atmospheric Administration located in Miami. The water current velocity, physical properties of the water, and sediment concentration during dredged material placement operations were measured with state-of-the-art acoustic instruments and in situ water sampling by a drogue pump-out system. One instrument suite centered around a 20- and 200-MHz Acoustic Concentration Profiler. This instrument provides an acoustic backscatter intensity from which relative sediment concentration can be inferred. The other instrument suite was a 150-MHz Acoustic Doppler Current Profiler (ADCP). The ADCP supplied data on the three-dimensional water current velocity field through the water column. These instruments were attached to a research vessel and used to track eight plumes during 2 weeks of field studies.

This first-time-ever monitoring of a deepwater disposal operation resulted in answers to many questions regarding the suitability of the existing disposal site. For the first time, there is proof that the vast majority of material being deep-ocean disposed is quickly reaching the bottom, and that the resultant plume is a small component of the total load. The sediment concentration and current measurements indicated that the suspended material dispersed rapidly as it moved in a northeasterly direction away from the sensitive coral reefs. This result confirms the predictions of the numerical model, namely, that use of the Miami ODMDS poses no risk to the coral reefs. Additionally, three-dimensional current data for the site now allow prediction of the effects of future disposal events.

As with any field endeavor in such a complex oceanic environment, questions remain. Concerns about the incidence of spinoff eddies from the Gulf Stream and the possibility of the associated currents carrying a dredged material plume onto the reefs are still being raised. However, this study demonstrated the effectiveness of the use of acoustic systems for environmental monitoring, and these remaining concerns can be effectively addressed using this equipment. The PLUME Measurement System intrument (PLUMES) being developed in the Dredging Research Program is seen as being an effective tool for site designation studies as well as for collecting baseline and real-time data necessary to meet the requirements of both state and Federal regulations. Field testing of PLUMES will be conducted in the fall of 1991 in conjunction with dredging operations at Canaveral Harbor, in an attempt to determine the fate of material placed in the offshore site. There is speculation that material from the site is moving back into the navigation channel, and it is anticipated that the PLUMES will be as effective at Canaveral as it was at Miami.

(There was no discussion after Mr. Skarbek's presentation.)

DISCHARGED DREDGED MATERIAL PLUME MONITORING

Dr. John R. Proni

The US Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) have been cooperating in the study of dredged material disposal plumes since 1975. The first cooperative study took place in Lake Ontario, where material dredged from the Genesee River was being discharged. This study was carried out under the auspices of the Dredged Material Research Program and had as its objective an initial evaluation of the utility of acoustical methodologies for the measurement and study of discharge plume parameters. The results from the Lake Ontario study were very encouraging and a second study was carried out in 1978 in the New York Bight, where dredged material from New York Harbor was being discharged. These pioneering studies showed that acoustical methodologies could be used to detect, track, and monitor discharge dredged material plumes. Some initial efforts were made to directly interpret acoustical data in terms of material concentration.

In the early 1980's, the USACE and NOAA worked together and developed an ultra-high frequency (3-MHz) acoustical system for studying resuspension due to surface waves at Fort Belvoir, VA. This device and devices derived from it have since found multiple applications, including the study of the possibility of dredged material resuspension at selected discharge sites.

Cooperation between USACE and NOAA continued with the initiation of the Dredging Research Program (DRP) in 1988. The first cooperative effort was the Mobile, AL, DRP Field Data Collection Project, which took place during the period 18 August - 2 September 1989. This experiment utilized three different acoustical methodologies: (a) the acoustical backscatter intensity information pioneered in the Lake Ontario studies; (b) the high-frequency resuspension study devices pioneered at Fort Belvoir; and (c) the acoustical Doppler methodology pioneered by private industry and NOAA. This highly successful effort yielded information of unprecedented quality on dredged material plume behavior.

The most recent cooperative effort was the Miami Harbor Dredging Project, which occurred in April and June 1990. The Miami Harbor discharge site had never been used before and was located in relatively deep water with a site depth averaging about 150 m. The value of acoustical methodologies was very clearly demonstrated in this experiment. Dredged material discharged in Miami Harbor was detected and mapped acoustically from the surface of the ocean all the way to the ocean bottom. These data unambiguously showed that the vast bulk of the discharged material landed in the designated site. Substantial concern had been voiced prior to the experiment as to whether this could occur. Additionally, acoustical methods revealed that the low concentration residual, which remained after a few minutes in the water column, drifted as a wispy cloud in a direction away from shore. It is very clear that acoustics will play a key role in addressing potential future environmental concerns.

Cooperation between USACE and NOAA is occurring at the present time and is planned to continue in the future. An NOAA representative, Dr. John R. Proni, will be a member of the PLUME Measurement System (PLUMES) Committee, which will serve to provide cooperation and guidance in acoustical and other discharge measurement technologies. A key cooperative effort will be the establishment of an acoustical calibration facility at NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami. NOAA's Ocean Acoustics Division will have the responsibility of operating this facility, in cooperation with USACE personnel.

DISCUSSION

Prof. Raichlen noted that there is some size segregation as the material drops through water. He asked how one differentiates between the effects of size and concentration with depth in order to come up with the concentration distributions. Dr. Proni replied that the plume behavior is regarded as occurring in two phases: a transient phase and a quasi-equilibrium phase. One of the remarkable things concerning these discharge plumes is the cohesiveness which is displayed in the material in order for it to drop to these great depths so rapidly. The fall velocities of the individual fine particles would not be as great. The material which is left in the water column is fines, and is effectively sorted by sizes.

Dr. Proni said that during the transient phase, where the particle size distribution changes so dramatically, it is more difficult to relate backscattered intensity to concentration. The transient phase occurs in a few minutes, and then you are in quasi-equilibrium. During the quasi-equilibrium phase, which starts a few minutes after discharge, the rate of change of the particle size distribution should be relatively slow. If you have an essentially constant particle size distribution, then these kinds of estimates can be made. Many more field samples are needed to validate this view of a transient and a quasi-equilibrium phase.

WETLANDS RESEARCH PROGRAM OVERVIEW

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The US Army Corps of Engineers (USACE), in performing its missions and responsibilities, directly affects wetlands and must consider the effects of its projects and decisions on wetlands. In its traditional role, the Corps has responsibility for flood control, hydropower production, navigation, water supply storage, and recreation. Section 404 of the Clean Water Act, Executive Order 11990, and the President's stand on "No Net Loss" of wetlands recognize a need to minimize the destruction, loss, or degradation of wetland functions and to preserve and enhance the value of wetlands. They have as their objective to maintain and restore the physical, chemical, and biological integrity of the nation's water quality. Relative to project planning, construction, operations and maintenance (primarily dredging), and other accompanying activities in wetlands (Sec. 404), the Corps' needs are diverse. These needs include improved and cost-effective methods and techniques and knowledge bases to (a) delineate wetlands and determine their functions and value, (b) minimize wetland impact, (c) create and restore wetlands, (d) determine the cumulative impacts of wetland losses, and (e) incorporate this knowledge into a sound logical approach to problem-solving and mission activities.

The magnitude of the problem is that nearly all activities of the Corps of Engineers are affected by wetlands-related issues. As such, the central purpose of the Wetlands Research Program (WRP) is to combine the environmental and engineering disciplines to provide the best technology and the most cost-effective tools and methods to meet Corps and national needs. The information and techniques that will be developed in this program will be widely shared through coordination and cooperative efforts with other Federal and state agencies and a vigorous program of information dissemination and transfer.

The program has been developed to address the following task areas:

Interagency Coordination and Cooperation. Interagency coordination, cooperation, and communication are extremely important aspects of the WRP.

Opportunities for exchanging information and cooperative wetlands work efforts will be explored at both the regional and national levels.

Technology and Information Transfer. Technology transfer and information transfer will be key focuses of the WRP, and will provide mechanisms for disseminating information from Task Areas to USACE offices, other Federal, state, and regional agencies, academia, private organizations, and the public at large.

Delineation and Evaluation of Wetlands. All projects associated with wetland areas require decisions regarding delineation of wetland boundaries and assessment of functions and values of wetlands. Three work areas will be addressed: (a) delineation (hydric soils, hydrophytic vegetation, and hydrology); (b) evaluation of functions and values (refine Wetland Evaluation Technique, regional and local importance); and (c) determination of priority wetlands.

Restoration and Development of Wetlands. The USACE has restored, built, or enhanced numerous wetlands sites. A variety of engineering and environmental techniques have been developed and tested. However, there are areas where the knowledge base is not fully adequate to address restoration or development of certain wetland types. The USACE offices and their permit applicants are in immediate need of written scientific and engineering guidelines and procedures for wetlands restoration and construction. To accomplish the broad range of work within this Task Area, four work areas will be developed: (a) improved design criteria (hydrology for selected wetland types, soils transfer and placement, baseline vegetation criteria for establishment and maintenance, and engineering procedures and construction techniques); (b) development of standard monitoring and success criteria; (c) techniques for ensuring success of restored or developed wetlands; and (d) wetland demonstration and/or evaluation projects with full interagency cooperation and coordination.

Stewardship and Management of Wetlands. The USACE owns or controls nearly 9,000,000 acres of land managed for natural resources; much of this land involves water resources (reservoirs, lakes, rivers, wetlands). Work areas to be addressed include: (a) methods to predict impacts; (b) developing wetland change assessment techniques; (c) wetlands inventory and evaluation procedures and an information system; (d) identification and assessment of management technology; and (e) demonstrations of stewardship and management of wetlands.

Critical Processes of Wetlands. An understanding of critical wetland processes is vital to effective restoration, development, and management of existing and proposed wetlands. Work areas being developed are: (a) hydrology and hydraulics; (b) sedimentation and erosion; (c) water quality; and (d) soil chemistry.

The WRP officially began 1 October 1990, and will terminate in 3 years on 30 September 1993.

DISCUSSION

Prof. Dalrymple asked how much money was involved in the program, and how scientific cooperation and input from various agencies and academia was accomplished. He also asked if there were any oversight committees or individuals reviewing the program. Mr. Theriot said that the program has $22 million over 3 years: $3 million the first year for developing the program and evaluating sites; $11 million the second year to do the major part of the information gathering and synthesis; and $8 million the third year to write the guidance documents and wrap it up.

Mr. Theriot said that at the national level they were working on a strategy that would involve various Federal agencies, to provide partnering for the various projects. At the US Army Engineer Waterways Experiment Station level, they are working with the Environmental Protection Agency through a memorandum of understanding (MOU) that allows cooperation on certain projects. There are a number of efforts, primarily through MOU documentation. He said there are 15 field people from Corps Districts that perform an annual program review, and six technical monitors from Headquarters, USACE. Dr. Roper, from the Directorate of Research and Development, is trying to affiliate the program at the national level to get an oversight committee.

Mr. Stanley T. Arakaki asked about the Delineation Manual and the Wetlands Evaluation Techniques Manual. Mr. Theriot said the Wetlands Evaluation Techniques Manual will continue to be refined.

WETLANDS RESEARCH PROGRAM: COASTAL INITIATIVE

Joan Pope
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and
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Research related to coastal wetlands has been conducted for many years as an ancillary activity to other coastal studies. Traditional coastal research has focused on the wetlands as: geomorphic and stratigraphic indicators of coastal system evolution, as hydrodynamic boundary conditions, as elements in dredged material management projects, as shoreline erosion control zones, and as part of the sediment transport system. With the development of a national and Corps policy to enhance and protect wetlands, and with the advent of the Wetlands Research Program (WRP), we now have the mission and the opportunity to dedicate resources toward those issues that are important to the evolution, preservation, and reconstruction of coastal wetlands. The Coastal Engineering Research Center (CERC) and other Corps laboratories involved in the WRP are presently initiating studies on the physical, chemical, and biologic aspects of coastal wetlands.

Of primary interest to CERC and the coastal engineering community are those physical processes and engineering options that concern intertidal and wave-influenced wetlands. Wetlands are defined as riverine, depressional, or intertidal. "Coastal" wetlands are considered as intertidal, however, a number of depressional wetlands (i.e., reservoirs and larger lakes) are also affected by wave processes.

During the early planning phase of the WRP, researchers at CERC were asked for study ideas and their perception of technology needs. Over two dozen solid proposals were submitted! These proposals covered such subjects as measuring and predicting hydrodynamic processes, developing geomorphic classification criteria, analyzing erosion processes, developing sediment budgets for wetlands, evaluating the physical functions of wetlands (storm surge dampening and retention), applying dredged material handling technology to wetlands, measuring and monitoring systems, and examining erosion control devices and techniques. The level of awareness within CERC of wetland-related issues and sensitivity to wetlands as a physical system were remarkable.

As discussed by Mr. Theriot in his overview, the WRP is a complex interlaboratory program involving a number of research disciplines. Not all coast-related wetland work is being conducted using CERC researchers. This presentation will focus on those activities occurring at CERC and should not be considered as providing a comprehensive overview of the WRP "Coastal Initiative." For example, research in the areas of wetland delineation and evaluation, minimizing and predicting impacts, improved design criteria, managing of wetlands, etc., includes coastal wetland systems, but the focus and conduct of that work is oriented elsewhere than in the arena of coastal processes and engineering. The CERC's involvement in the WRP is primarily in the areas of "Critical Processes" and "Wetland Field Demonstrations."

Although the Critical Processes Task Area is being managed at CERC, it includes research in other labs. The primary objective of this Task Area is to transfer to field engineers and scientists the important facets of our current understanding of key physical, chemical, and biological processes which are known to control wetland functions (i.e., "What makes a wetland work?"). A second major objective is to provide a computer-based capability for quantifying some of the most important processes, their interactions, and how these affect the functioning of wetlands. Research planned that is of specific coastal interest includes surface water processes, wind-wave processes, and wave-induced erosion. Additional research is planned in groundwater processes, effects of vegetation on surface flow and sedimentation, surface sediment processes, demonstrating wetland ecosystem simulation, water quality processes, and soil and vegetation processes. The research database for these elements will be generated through a field study site, still to be selected. The site should be one that is an enclosed body of water surrounded by wetlands and some shoreline variability. This site will be used to examine shallow-water wave formation and propagation, wave climatology, interaction of shore geometry with the wave climatology; to evaluate historical shoreline changes; to monitor in situ erosion rates, and to define the role of vegetation and material type in calculating erosion rates.

The primary charge of the Task Area "Wetlands Restoration, Protection and Establishment" is to demonstrate that the Corps has successfully restored and established wetlands in the past, is currently doing so, and can continue to do so. A major emphasis is that the work should be performed in a spirit of interagency cooperation. To satisfy these charges, "Wetland Field Demonstrations" was developed to monitor and analyze a variety of wetland habitats, 26 study sites in all. Presently, three sites are being coordinated and monitored by CERC. The first two sites fall under the general research area titled "Coastal Shoreline and Channel Protection."

Aransas National Wildlife Refuge (ANWR) & West Bay, TX. The ANWR and West Bay sites are located along the Gulf Intracoastal Waterway of Texas. The sites experience erosion of wetland habitat due to boat-generated wake and wind-wave attack in the more exposed reaches. This erosion threatens to breach barriers protecting landward pools and prime habitat for a variety of wildlife, including the endangered whooping crane in the ANWR. In 1990, CERC assisted the Galveston District in conducting site investigations and developing alternative shore protection strategies as a reimbursable study. Presently, the Galveston District is coordinating the installation of shore protection measures. The WRP will monitor the effect and success of these shore protection measures.

Bodkin Island Restoration, Chesapeake Bay, MD. Bodkin Island, located in Chesapeake Bay, was formerly about 50 acres in size, but has eroded, leaving approximately 1 acre. Although the island is the best remaining black duck nesting ground in the region, brood habitat no longer exists at this site. Through coordinated efforts of the WRP, the Baltimore District, and the US Fish and Wildlife Service, the island will be increased in size to about 7 acres and will include an intertidal wetland (brood habitat) using material dredged from a nearby navigation channel. Structural enhancement of the shoreline and the incorporation of erosion control devices are also being considered. The WRP will continue to monitor the development of the wetland within the island and to assess the success of the shore protection measures.

The third demonstration site coordinated by CERC is under the general research area titled "Comparisons of Engineering Restoration Designs in Coastal Louisiana."

Mississippi River Ship Channel at Southwest Pass, LA. Southwest Pass is the southernmost end of the Mississippi River navigation channel. Dredging operations in the pass have kept the channel open and have created intertidal wetlands through the unconfined placement of the dredged material. However, continued development of wetlands along the pass is becoming more costly because the dredged material must be placed further from the channel. The WRP will evaluate the efficiency and effectiveness of dredging techniques used to build wetlands in coastal Louisiana, based on the study of Southwest Pass. Other demonstration sites (in the same research area), which use other techniques for building wetlands in coastal Louisiana, are being evaluated. The WRP intends to develop guidance on the most practical and effective methods for use at a given site.

DISCUSSION

Prof. Reid asked if there were attempts made to monitor changes during severe tropical storms so that they could be distinguished from long-term changes. Ms. Pope said that the logistics of the monitoring were just being established. At certain sites, it will be critical to look at the effects of episodic events. Those effects may be storms at some sites, and floods at other sites.

Prof. Raichlen asked how the sites were chosen. Colonel Fulton said there were about 300 sites nominated by host Districts. With the funds available, the program is limited to studying about 25. These sites had to be selected to get a diversity in ownership, and to cover the eight different task areas that were discussed. Ms. Pope said there was an in-house review group headed by Dr. Mary Landin with representatives of the other task areas. There was a desire to look at a full range of wetlands ranging from Arctic wetlands to bottomland hardwoods, prairie potholes, and open coastal areas. It was necessary to look at what could be done in the timeframe of the program, and which projects had research potential. She indicated a list could be provided of demonstration sites being handled under the Wetlands Research Program.

Mr. Theriot said there was a fact sheet available on each of the demonstration sites. These give information on the specific research task that is being addressed, and other information such as who the partner is, etc.

Mr. Holliday asked if there was a database available now that documented areas where the Corps has developed wetlands sites, and does it address successes and failures. Mr. Theriot said there was no mechanism in place right now to do that, but that it was something that was needed. Many of the people at the US Army Engineer Waterways Experiment Station working on this program also worked on the Dredged Material Research Program, so that information is available. Ms. Pope noted that one of the research areas is comparing man-made areas to natural wetland areas to learn how successful man-made areas are relative to the natural areas.

Mr. Holliday asked if there would be any sites where dredged material could be used to maintain the site, i.e., periodically pumping material onto the site to offset erosion that might occur after a wetland area is established. Ms. Pope said that will be the approach at the Southwest Pass site, and also certain portions of West Bay and Aransas Pass. It is necessary to have enough time for mature wetlands to develop, so erosion must be controlled. There will be a combination of confined and unconfined use of dredged material.

Mr. David N. Barilovich asked if computer programs being used to evaluate wetland erosion could also be used to look at other shoreline erosion. Ms. Pope said there were a number of areas of research looking at shoreline erosion.

OIL SPILL UPDATE

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Public Law 101-380, also known as the Oil Pollution Act of 1990 (OPA-90), was passed by Congress and signed into law on 18 August 1990. The OPA-90 touched on many of the problems associated with oil spills and aggressively authorized studies and funding to solve those problems. The US Coast Guard (USCG) is the Federal agency most affected by the Act, but the US Army Corps of Engineers (USACE), the National Oceanic and Atmospheric Administration, the Department of State, the Maritime Administration, the Department of Commerce, and the Department of the Interior are also prominent in developing and implementing parts of OPA-90.

The USACE is specifically instructed to perform a "Dredge Modification Study." Section 4112 instructs USACE to study and demonstrate the feasibility of modifying dredges to make them usable in removing discharges of oil and hazardous substances. The section further instructs USACE to submit a report to Congress on the results of the study, including recommendations for implementing the results, within 1 year of passage of the Act.

Another part of OPA-90 that is of immense interest to USACE is Title VII - Oil Pollution Research and Development (R&D) Program. Title VII establishes an Interagency Coordinating Committee on Oil Pollution Research, which is chaired by USCG with USACE as a member. The Coordinating Committee has formulated and submitted to Congress an Oil Pollution Research and Technology Plan that (a) identifies agency roles and responsibilities; (b) assesses current status of knowledge on oil pollution technologies and environmental effects; (c) identifies significant research gaps; (d) establishes research priorities and goals for technology development; (e) estimates resources and timetables needed to conduct research and development; and (f) identifies regional needs and priorities for research and development.

The OPA-90 also required of the Coordinating Committee an Oil Pollution R&D Program. This R&D Program shall "provide for research, development, and demonstration of new or improved technologies which are effective in preventing or mitigating oil discharges and which protect the environment..." The R&D Program is to address items such as vessels; recovery, removal, and disposal techniques; management and decision-making techniques; public health and protection for clean-up workers; environmental impacts and restoration; and evaluation of satellite-based traffic management systems. The Program also provides for (a) the development of improved models and capabilities for predicting the environmental fate, transport, and effects of oil discharges; (b) the development of methods for assessing damages, including economic, to natural resources; (c) identification of types of particularly sensitive ecological areas and means that can be implemented to monitor and protect those areas should the need arise; and (d) the collection of environmental baseline data in particularly sensitive ecological areas.

The Act provides for evaluations, demonstrations, and simulations on regional, national, and international scales. Funds are authorized, but not appropriated, on a regional and national basis, for five fiscal years to assure that provisions of the Act are carried out.

The USACE is involved in Oil Spill activities in a number of ways. the USACE is a member of the Interagency R&D Coordinating Committee. As such, USACE participated in identifying needs and setting priorities. The USACE is assisting USCG in performing a number of their tasks, particularly where Environmental Assessments or Environmental Impact Statements are required, or where regulations implementing requirements of the Act are to be prepared and disseminated. An "Engineering Study" of the USACE hopper dredge fleet, where modifications to that plant would make it more efficient for recovering floating oil, has just been completed. This study will become part of the report required by OPA-90 that is to be submitted to Congress.

The USACE can look forward to significant participation in the R&D effort when funds are appropriated by Congress to perform the research identified under the Oil Pollution R&D Program.

DISCUSSION

Dr. Proni noted that acoustic technology used to detect dredged material could possibly be used to detect subsurface oil signatures. Technology being developed under the Dredging Research Program might be adaptable for that purpose. He also said that it is within the realm of present technology to use real-time monitoring devices to detect subsurface oil approaching a water intake.

PANEL
COASTAL FLOODING/EROSION - GULF COAST PERSPECTIVE AND INITIATIVES

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GULF OF MEXICO PROGRAM

Thomas R. Campbell

The Gulf of Mexico Program is an interagency effort for resolving complex environmental problems associated with man's use of the Gulf of Mexico. The major product of this effort will include a Framework for Action that will assure appropriate coordination of the activities of all Federal and state agencies in the Gulf of Mexico. The development of the Framework for Action is estimated to take 5 years.

The program's objective is to sustain the development of the gulf area while protecting the environmental quality through an integrated and cooperative approach by establishing a long-term working relationship with all interests.

The program was initiated and organized by the Environmental Protection Agency (EPA) Regions 4 and 6. Several memorandums of agreement have been executed both within the EPA and with other Federal and state agencies in support of the program. The EPA has established and staffed the program office, which is located at the Stennis Space Center near Slidell, LA.

The program is of significant interest to the Corps. Activities and reports developed as part of the program will have significant effect on public and political attitudes relating directly to Corps projects and programs. The program will also provide a significant source of information and data which will be useful in Corps projects and programs. While the primary focus may be on environmental concerns, the programs will definitely impact the full range of Corps interests, including flood control, coastal projects, navigation, as well as regulatory control functions. While activities throughout the Gulf Coastal States will be investigated, coastal Louisiana will be of special interest. Corps representatives from all coastal Districts in the Southwestern Division, the Lower Mississippi Valley Division (LMVD), and the South Atlantic Division are included on the appropriate subcommittees of the Technical Steering Committee and are necessary for EPA to achieve the objectives of the program.

The LMVD has been assigned to coordinate all Corps participation in the program activities. The Division Commander is a member of the Policy and

Review Board and will participate in the decisions concerning the direction of the program. In addition, LMVD has provided staff assistance to the program office at the Stennis Space Center to assist with the program activities and to assure that appropriate Corps participation is accomplished and that Corps concerns and interests are incorporated into the program management plans.

GULF OF MEXICO PROGRAM
COASTAL AND SHORELINE EROSION SUBCOMMITTEE
THE MAGNITUDE OF THE PROBLEM

Thomas R. Campbell

Most components of the coastal system are undergoing severe erosion. Throughout the gulf, erosion rates vary from 1-30 m per year, only a few areas remain stable, and even fewer areas experience accretion. Causes of erosion are natural aging processes (subsidence, normal wind and weather fronts, major storm events, and sea-level rise) and human alterations (jetties, channels, levees, and dams). The impacts of erosion include loss of habitat, reduced fisheries resources, saltwater intrusion, and loss of or degraded recreational use which, when combined, accelerate the loss of the natural environment, jobs, and income. There are some site-specific solutions, such as beach nourishment and sediment bypassing; however, the problem is system-wide. There is general agreement that the northern gulf is dominated by a net westerly drift of sediment and that there are seasonal fluctuations, but little is known about these sediment movements and their relationship to the losses and gains at specific problem areas. Can these net sediment movements be directed in beneficial ways? Can major diversions of sediment reduce erosion or shoreline losses, and will such efforts be cost-effective?

COASTAL EROSION AND WETLANDS LOSS IN LOUISIANA: STATUS OF US GEOLOGICAL SURVEY COASTAL RESEARCH ACTIVITIES

S. Jeffress Williams

Introduction

More than one half of the United States population currently lives within a 1-hour drive of the nation's marine or Great Lakes coasts, and the density of population and development in the coastal zone is predicted to increase into the 21st century. At present, developed coastal areas face potential loss of life and billions of dollars in property damage because of long-term coastal erosion and storm effects. In addition, valuable coastal wetlands and estuarine habitats are being rapidly altered as a result of natural and human-induced factors. All 30 states bordering a coast are experiencing erosion and wetlands deterioration, and 26 of these states suffer from an overall net erosion of their shorelines. The National Academy of Sciences forecasts an increase in sea-level rise; this would accelerate coastal erosion and wetlands degradation.

The physical processes causing wetlands loss and barrier island erosion are complex and varied, and many are not well understood. In addition, the technical and academic communities debate about which of the many contributing processes, both natural and human-induced, are most significant. Controversy also surrounds some of the measures that are being proposed to mitigate erosion and reduce wetlands loss. Much of the debate is focused on the reliability of predicted results of a given management, restoration, or erosion mitigation technique. With better understanding of the physical processes of wetlands loss, such predictions will become more accurate, and a clearer consensus should appear on how to reduce erosion and land loss.

Role of the US Geological Survey in Coastal Erosion and Wetlands Loss Research

As the primary Federal agency for conducting research and information gathering on all earth-science topics, the US Geological Survey (USGS) is engaged in studies focused on improving scientific understanding of the physical processes affecting coastal environments. In 1991, the USGS's Coastal Geology Program consists of the following eight major studies: (a) Louisiana Barrier Island Erosion, (b) Louisiana Wetlands Loss, (c) Southern Lake Michigan Coastal Erosion, (d) Alabama-Mississippi Coastal Erosion and Pollution, (e) Western Louisiana-East Texas Erosion, (f) Lake Erie (Ohio) Erosion, (g) Massachusetts Bay Pollution, and (h) Great Lakes and Florida Wetlands Loss. Each study is being done in close cooperation with other Federal agencies (e.g., the US Fish and Wildlife Service (FWS), the US Army Corps of Engineers (USACE), the Environmental Protection Agency, and state geological surveys, as well as academic researchers. The two Louisiana studies are described below:

Louisiana Barrier Island Erosion Study. Much of the territory bordering the Gulf of Mexico is undergoing shoreline erosion. Louisiana, however, has the greatest rate of erosion compared with other gulf region states, and also with other coastal states. Much of this erosion occurs along the barrier islands, which act as buffers, protecting wetlands and estuaries landward from the effects of storms, ocean waves, and currents.

In 1986, the USGS and the Louisiana Geological Survey (LGS) began a 5-year study that focused on the processes causing barrier island erosion. The study areas extended from the Isles Dernieres to Sandy Point and to the Chandeleur Islands east of the Mississippi River Delta. Because long-term erosion of Louisiana's barrier islands is due to both sea-level rise relative to the land and diminishing sand supply, the primary objectives of this study were to quantify processes related to sea-level rise and sand supply, and to present the results in a form that can be applied to practical problems such as predicting future changes. The study was divided into three main parts:

a. Investigate the geologic framework of the Mississippi River deltaic plain where the barrier islands have formed and migrated landward. This involved using sediment cores and geophysical profiles to provide a broad regional understanding of the historical development of the barrier islands and a conceptual view of the processes of barrier island erosion. Comparisons of archival maps and photographs of the coast from the past 135 years yielded accurate measurements of the geomorphic changes taking place.

b. Develop a better quantitative understanding of the processes responsible for erosion. The focus was on only a few of the many physical processes, including relative sea-level rise, overwash, net offshore sediment transport, and gradients of sediment transport. Careful analyses of tide gage records showed a progressive rise in relative sea level over the entire region, with local rates exceeding 1 cm/yr. Most of the rise is due to compaction and subsidence of the recent deltaic sediments. A series of field experiments and modeling efforts were undertaken (e.g., direct measurements of overwash of the Isles Dernieres barrier islands during winter storms and hurricanes).

c. Assemble the research results as digital data sets, atlases, and technical reports for use by coastal scientists, planners, and engineers. Applications of the study results include developing better techniques for determining the rate at which artificially nourished beaches should be replenished and predicting future shoreline erosion so coastal planners can plan construction at a safe distance landward from the eroding shoreline.

This study was completed in September 1990, and final products are being completed.

Louisiana Wetlands Loss Study. Of the 48 conterminous states, Louisiana has 25 percent of the vegetated wetlands and 40 percent of the tidal wetlands. These coastal wetlands, including the associated bay and estuary environments, support renewable natural resources estimated at a value of $1 billion per year. However, an estimated 80 percent of the nation's tidal wetlands area loss has occurred in Louisiana. The areas of greatest loss are in the modern Mississippi River Delta and the Barataria and Terrebonne basins to the west. Map comparisons by several scientists have been used to show that wetlands loss has steadily increased during the 20th century to an estimated 100 km^2/year by 1978, the latest year for which detailed measurements are available. If this rate of wetlands loss continues, the USACE estimates that in the next 50 years, nearly 1 million acres of Louisiana wetlands will be converted to open water.

Conceived as a natural extension of the Barrier Island Erosion Study, this USGS study began in late 1988 in cooperation with the FWS and Louisiana state agencies. Emphasis is on understanding the critical physical processes that cause the extreme rate of wetlands loss in coastal Louisiana and identifying the best management practices to address those losses

This USGS and FWS wetlands study includes four parts: (a) baseline data is being compiled and put into a computer-based Geographic Information System; (b) research is being conducted on a basin scale to understand some of the critical processes causing wetlands loss; (c) at specific sites, research is being conducted on the effects and utility of various wetlands management activities on the processes; and (d) the information and results from these studies are being passed to the user community by means of reports, maps, and workshops.

The wetlands study elements dealing with research on some of the critical physical processes are being undertaken by USGS scientists as well as scientists at LGS and Louisiana State University under contract with the USGS. Field studies are under way in two separate hydrologic basins, one sediment-rich and the other sediment-poor, in order to compare and contrast the dominant processes in each. Investigations are nearly complete in the sediment-poor Terrebonne Basin-Timbalier Bay and parts of the Barataria Basin; field studies in the sediment-rich Atchafalaya basin started in 1991. Research elements under investigation for each basin include meteorological forcing events, fine-grained sediment dispersal, saltwater and freshwater dispersal, physical processes of marsh deterioration, wetlands soil development, and subsidence-soil compaction. In addition, a study contracted to Coastal Environments, Inc., is examining the effects of small-scale freshwater diversions from the Mississippi River on brackish marshes adjacent to the levees. The duration of the USGS-FWS Wetlands Study is anticipated to be 6 years.

Summary

In addition to the eight studies currently under way in USGS's Coastal Geology Program, several other activities are in progress. As directed by Public Law 100-220, the USGS and the National Oceanic and Atmospheric Administration have developed a plan for conducting geologic studies along and remapping the coastal zone of the United States portion of the Great Lakes.

The plan, submitted to Congress in December 1989, recommends a 10-year effort of phased surveys and would include research contributions by agencies in each of the affected states. To date, Congress has provided only limited funds for implementing the study plan.

Congress also directed the USGS to formulate a plan to extend and expand the present regional coastal studies into a research program of national scope. This effort included obtaining recommendations from other Federal agencies as well as the appropriate agencies in each of the coastal states. The plan, prepared and submitted to Congress in May 1990, addresses research needs for coastal issues: erosion, wetlands loss, polluted sediments, and marine hard-mineral resources.

NON-FUEL MINERAL RESOURCE ACTIVITIES OF THE EEZ GULF OF MEXICO TASK FORCE

T. John Rowland

The Department of the Interior's Minerals Management Service (MMS) and the states of Alabama, Mississippi, Louisiana, and Texas entered into a cooperative agreement referred to as the Gulf of Mexico Task Force in 1987 to evaluate the potential development of marine mineral resources in the Gulf of Mexico. The initial effort utilized existing databases for preliminary evaluations of the occurrence, location, and economic feasibility of developing the marine mineral resources. A report, "Preliminary Assessment of Non-Fuel Mineral Resources in the Outer Continental Shelf Exclusive Economic Zone of the Gulf of Mexico," was issued in April 1989.

The Gulf Task Force, composed of the MMS, the Geological Survey of Alabama, the Louisiana Geological Survey (LGS), the Mississippi Mineral Resources Institute, and the Texas Bureau of Economic Geology recommended that Federal agencies with the necessary expertise, such as the US Geological Survey, the Bureau of Mines, and the US Army Corps of Engineers be included in the task force. Further, the initial study identified sand as the most abundant offshore resource, but found that the abundance of onshore sand resources, along with a depressed market, dictated that the only immediate use of the sand would be for nearby beach and barrier island nourishment projects. Of the resource targets identified, only Ship Shoal was characterized at a level sufficient for detailed, site-specific analysis. Many other sites offshore Alabama, Louisiana, Mississippi, and Texas exist but more data (high resolution reflection seismic lines and vibracores) would be needed before potential sites for sand resources could be selected for detailed resource characterization. Preliminary indications are that heavy mineral placers of potential economic interest occur in several areas of the gulf; however, the heavy mineral investigations cited by the task force report did not evaluate these minerals as a potential economic resource.

In September 1989, this joint state-Federal task force was extended to assess the feasibility of harvesting sand from Ship Shoal for placement on the Isles Dernieres, a barrier island complex offshore Louisiana. A review of the coastal erosion and accretion trends along the coastline of the US Gulf Coast clearly illustrates that the greatest rates of erosion are found in the Mississippi River Delta and chenier plains of Louisiana where rates exceed 10-20 m/year. Of all the Alabama, Louisiana, Mississippi, and Texas coastal areas, the Terrebonne and Barataria barrier-built estuaries will be faced with the greatest coastal erosion and land loss in the next 10 years. If sea-level rise forecasts are accurate for the next century, an immense demand for sand for coastal erosion control exist in the Gulf States.

The objective for the 1989-1990 Gulf Task Force coordinated by the LGS was to coordinate and review a geologic, engineering, economic, and environmental analysis of the Ship Shoal-Isles Dernieres area where the near-term use of sand is likely for beach nourishment and barrier island restoration. The Isles Dernieres are experiencing very severe land losses. Ship Shoal sand represents a supply of replenishment material available to mitigate continued Isles Dernieres land losses.

The 18-month study, jointly funded by MMS and Louisiana State University, is examining the environmental, geologic, engineering, and economic aspects of mining the offshore sand deposits. Estimates of the relevant factors such as overburden, areal extent and thickness, resource volume, and sand textural characteristics were developed by the geological analysis. The engineering development analysis assessed various development scenarios considering alternative dredging schemes and technologies as well as the associated costs. The Coastal Engineering Research Center at the US Army Engineer Waterways Experiment Station was subcontracted by the task force and worked with the LGS on this task. The physical environmental analysis used existing data to characterize the physical environment and to determine the potential impact of development on the geomorphology of the shoal and the local wave refraction patterns. The CERC conducted the wave refraction pattern analysis for Ship Shoal with input from LGS. Data were collected concerning competing onshore sand sources proximal to beach nourishment projects. Costs and permitting issues associated with offshore and onshore mining operations were assessed. The MMS performed the economic analysis (cost per cubic yard of delivered material) of the site for each scenario over a range of project sizes. A final report with recommendations reflecting comments from the Task Force and MMS was scheduled for completion 31 May 1991.

During the upcoming year, the Gulf Task Force is considering pursuit of investigations possibly including such topics as: (a) a nearshore reconnaissance to evaluate shell deposits off the Gulf States, (b) shallow seismic operations offshore Mississippi and Alabama for data concerning possible heavy mineral and shell resources, (c) further detailed evaluation of Ship Shoal, depending on industry interest and the recommendations of the Ship Shoal Project Report, and (d) sand resource assessment off the Texas coast using the Ship Shoal Project as a methodology prototype.

DISCUSSION

Mr. Arakaki asked if there was a marine minerals inventory for Hawaii. Mr. Rowland said that they did have information for Hawaii. Much of the information comes from the Marine Minerals Technology Center at the University of Hawaii. It includes information on sand in and around the Hawaiian Islands.

COASTAL LAND LOSS IN LOUISIANA
STATUS OF THE LOUISIANA GEOLOGICAL SURVEY RESEARCH ACTIVITIES

Dr. Shea Penland

Research Strategy

Coastal erosion and wetland loss are serious and widespread national problems with long-term economic and social consequences. The highest rates of erosion and wetland loss in the United States, and possibly the world, are found in coastal Louisiana. Coastal land loss severely impacts the fur, fish, and waterfowl industries, valued at an estimated $1 billion per year, as well as the environmental quality and public safety of south Louisiana's sea-level citizens. In addition, the region's renewable resource base depends on the habitat provided by these fragile estuarine ecosystems. Understanding the geomorphological processes, both natural and human-induced, that control barrier island erosion, estuarine deterioration, and wetland loss in Louisiana is essential to evaluating the performance of the various restoration, protection, and management methods currently envisioned or employed. Louisiana's coastal problems illustrate the importance of understanding the processes driving coastal land loss. Many solutions to coastal land loss problems emphasize stopping the result of the geologic process and give inadequate consideration to the process itself. This approach results in engineering solutions that rely on expensive brute force rather than more sophisticated, less expensive approaches that operate in concert with natural processes revealed by scientific study. This lack of understanding leads to oversimplified concepts and the false hope that easy solutions exist today. Louisiana's coastal land loss crisis is of national significance and is increasing as population and industrial growth into fragile coastal areas continues, and if sea-level rise is brought on by global climate change, stress on Louisiana's coastal environments will increase substantially. Ignorance and disregard of the geologic processes that constantly reshape Louisiana's coasts are tragically intensifying the conflict between man and nature. Coordinated multidisciplinary efforts are needed to improve our understanding of how coastal Louisiana formed and evolved. A clear understanding of how coastal environments have formed and the natural changes they have undergone in the recent geological past can be critical in predicting future conditions with confidence . Many different scientific groups must be involved to provide critical expertise in specific fields of research. Pro-active cooperation among Federal, state, and local agencies is essential to ensure that this scientific expertise is applied in site-specific studies to solve the individual coastal problems faced by Louisiana. Concerted efforts focused on understanding coastal land loss in Louisiana require efficient coordination to get maximum return from the limited resources available. Some engineering practices and human activities that are incompatible with natural processes and that cause long-term harm to the coast can be modified or removed to lessen their effect. In other cases, erosion mitigation techniques that closely replicate natural processes, such as beach nourishment, sand dune creation, and shoreline restoration, can be used. In extreme circumstances, abandonment and relocation of coastal communities might be the best alternative. Dealing effectively with the present coastal erosion and wetland loss crises in Louisiana and resolving future conflicts will require a combination of solutions that must be based on long-term societal needs and on sound scientific and technical knowledge, rather than emotional responses to short-term desires. Results of scientific investigations must be clearly communicated to coastal planners, engineers, and managers as well as political decision makers and the public. Only when these diverse groups understand the range of management approaches, the social, financial, and environmental costs, and the risks associated with each approach, can prudent and enlightened decisions be made.

Research Program

The Coastal Geology Program of the Louisiana Geological Survey (LGS) was established in 1982 to investigate processes affecting coastal erosion and wetland loss, to conduct coastal geology and geomorphology research, to document natural resources, to provide geoscience education, and to develop new programs in support of Louisiana's efforts to restore and develop the coastal zone. Program success and increasing emphasis on coastal-related issues led to expanded efforts and full Section status in 1988. The research mission of the Coastal Geology Section focuses on four themes.

a. *Conduct basic and applied coastal geomorphologic and geologic research.*

b. *Conduct hard mineral resource exploration.*

c. *Develop coastal mapping and geographic information system (GIS) strategies consistent with local, state, and Federal agencies.*

d. *Provide technical assistance and geoscience information for local, state, and Federal agencies as well as the private sector.*

Coastal Geology Section research focuses on processes affecting coastal erosion and land loss in Louisiana and other gulf coast areas. Topics include sea-level rise, subsidence, storm impacts, wetland loss, sedimentation balance, wetland soil development, geological framework, fluvial processes, and geomorphic and shoreline change analysis. Techniques for evaluating these factors include accurate computer mapping and aerial photography interpretation, repetitive videotape surveys, analysis of tide gage data, and interpretation of vibracore and shallow seismic data. Applied research topics focus on human impacts in the coastal zone, performance of coastal protection structures, and development of coastal protection concepts and strategies. These data are archived in a GIS-type format to be reviewed as necessary. The Coastal Geology Section is also conducting investigations to inventory potential hard mineral resources found in Louisiana's coastal zone and on adjacent continental shelves. In support of ocean mining in state and Federal waters, the Coastal Geology Section is conducting inventories of strategic minerals in the northern Gulf of Mexico. These data are leading to the identification of economically viable commodities that could provide beach nourishment and construction aggregate for coastal communities, thus providing economic stimulus and revenue for the states. Geological investigations are used to develop models from predicting the occurrence of hard mineral resources associated with surface and subsurface geologic features. In support of beach nourishment, barrier island restoration, and backbarrier marsh development in Louisiana, a State Nearshore Sand Resource Inventory is ongoing. This study identifies the location and quantity of sediment suitable for various protection schemes envisioned for the future. Prior to developing an understanding of the processes controlling the geologic evolution of coastal systems, a complete analysis of available historical data provides significant information regarding the recent development of specific environments. Generally, this entails creating a digital database of shoreline position from maps and aerial photographs. The Coastal Geology Section is currently developing accurate shoreline change databases for the northern Gulf of Mexico in support of ongoing geomorphic and geologic research activities. This involves three major efforts: (a) computer mapping/ computer cartography/CADD, (b) aerial photographic interpretation and rectification, and (c) GIS application. Long- and short-term rates of change are quantified for spatial and temporal analyses. These data document historical trends in coastal development related to incidental coastal processes and subsurface geological characteristics. The Coastal Geology Section provides technical assistance to local, state, and Federal agencies, as well as the private sector, on problems relating to coastal geology. Local assistance has been provided to parish governments on problems of sea-level rise and subsidence, sediment sources for barrier island restoration, coastal protection strategies, and other geoscience issues. At the state level, the Section provides assistance on coastal erosion and land loss studies, baseline data on exploration of strategic minerals on the Continental Shelf, and environmental information on the effects on mining these deposits. For the private sector, it has aided in the development of oil and gas exploration models and has assisted in the development of coastal protection and restoration concepts. The LGS is a central repository for coastal geoscience information. These data are accessible to public schools, various government agencies, and professional organizations. Topics include coastal geology, oil and gas exploration, strategic minerals, sand resources, coastal hazards, shoreline erosion, wetland loss, and coastal restoration. An educational video survey has often been used by news services.

DISCUSSION

Mr. W. Eugene Tickner noted that the New Orleans District would have additional information available in the future relating to work by Bridge and Kemp that Dr. Penland had cited. He also noted that the District is evaluating what the pit offshore of Grand Isle is doing to the wave energy hitting the beach.

EROSION, FLOODING, AND PLANNING IN THE COASTAL PARISHES OF LOUISIANA

James B. Edmonson

The six-parish region encompassing the South Central Planning and Development Commission lies within the terminus of North America's largest riverine system, the Mississippi. The region measures 4,682 square miles, of which 85 percent is open water or wetland habitat. Population of the region in 1990 was 308,907. With the majority of the region located within the 100-year floodplain, regionally recorded relative sea-level rise rates of 1.03 to 1.30 cm/yr., and accelerated erosion of the deltaic lobe, protection of homes, businesses, infrastructure, and esturine habitats is of major concern. Regional hazards include: tidal, backwater, and runoff flooding, saltwater intrusion, subsidence, and erosion.

After nearly 10 years of independent research on the effects of coastal erosion, in 1984, several parishes within the region became the first in the nation to officially recognize the effects of sea-level rise and the corresponding economic, social, and cultural implications of same. These parishes realized that sound management and control would have to be regional, multi-pronged, and long-term. Any program developed would have to be comprehensive in nature and require the support of local citizenry. This report describes the elements of the comprehensive approach taken, which include: research, education, lobbying, funding, coordination, and small- and large-capital construction projects.

The report concludes by dispelling the notion of "retreat" and outlines several recommendations for future action including: areawide wetland and shoreline management, revised land use controls and enforcement, control of oil and gas industry exploration techniques, development of a National Resource Extraction Impact Program, limited hurricane protection systems, and civics and coastal education programs.

(No significant discussion after Mr. Edmonson's presentation.)

COASTAL EROSION IN TEXAS

Sally S. Davenport

Of the 367 miles of Texas Gulf shoreline, approximately 60 percent is eroding at rates of between 1 and 50 ft per year. About 33 percent is stable, and 7 percent is accreting. Erosion is not confined to the Texas Gulf beaches; it also affects the bay systems, where it causes the loss of agricultural, industrial, and residential lands, and threatens the productive wetlands that serve as nursery grounds for sport and commercial fisheries. About two thirds of Texas bay shores are eroding at rates of up to 5 ft per year, and rates of 1 to 2 ft per year are commonly reported. In Chambers County, an estimated 46 acres disappear into East Galveston and Trinity Bays every year.

In the fall of 1989, the 71st Texas Legislature recognized that many coastal problems could not be solved at the local level but needed to be addressed in a comprehensive manner by the state. The legislature enacted Senate Bill 1571, which directed the Texas General Land Office (GLO) to develop a coastal management plan for state-owned coastal lands. During the year that followed, the GLO hosted public hearings to determine the coastal issues of greatest concern to the citizens of Texas. Shoreline erosion and dune protection, wetland loss, and beach access emerged as the most critical coastal issues. The GLO invited experts from the academic, environmental, and industrial communities as well as all levels of government to participate in consensus-building workshops to formulate recommendations for protection of coastal lands. Recommendations reached by consensus constitute the 1991 Texas Coastal Management Plan (CMP).

Proposed legislation that resulted from the CMP effort recommends that erosion-response demonstration projects be conducted and that the GLO be named as the state coordinating agency for coastal erosion. The bill also strengthens the state's Dune Protection Act, requiring all coastal cities and counties to establish a dune protection line and follow construction guidelines to protect primary or critical dune areas.

Coastal areas experiencing erosion and economic loss include:

a. Sabine Pass to Rollover Pass/Highway 87. In the fall of 1989, the State Department of Highways and Public Transportation closed the portion of Texas State Highway 87 within Chambers and Jefferson counties, from High Island to Sabine Pass. The closure was prompted by the dangerous conditions resulting from erosion along the highway. In some areas, the highway lies at the water's edge, protected only by a makeshift metal bulkhead. Erosion rates of 5 to 10 ft per year have made the highway increasingly susceptible to wave energy and storm damage. The elevation of the beach and adjacent coastal lands is less than 5 ft above sea level. Beaches are narrow and dunes are limited. The beaches and surrounding wetlands are frequently inundated by waves of even minor storms.

Since the closing of Highway 87, visitation to Sea Rim State Park has decreased by 50 percent. Local businesses in Sabine Pass are struggling because of the decline in tourism.

b. West Beach, Galveston Island. Galveston County is an important tourist area that records between five and six million visitors, spending nearly $300 million annually. The Galveston Island shoreline is eroding, with the highest rates occurring at the west end of the seawall (11.6 ft/year) and adjacent to San Luis Pass (33.8 ft/year). After the passage of Hurricane Alicia in 1983, shoreline erosion left approximately 300 structures on the beach seaward of the vegetation line, compelling the Attorney General's Office to enforce the state's Open Beaches Act and claim the eroded land for the state.

c. Sargent Beach. An example of severe coastal erosion is found at Sargent Beach, where the gulf shoreline is retreating at a rate of at least 33 ft per year. What makes the situation especially critical--besides the loss of homes and beachfront property--is the fact that less than 600 ft of land now separates the Gulf Intracoastal Waterway (GIWW) from the Gulf of Mexico. A breach in this strip of land would expose the channel to the open gulf, disrupting ship and barge traffic, which annually carries an average of 17 to 19 million tons of goods worth $20 billion.

Closing of the GIWW would be detrimental to the petrochemical industry and other industries along the canal, which provide more than 147,000 jobs. Valero Energy claims that its billion-dollar facility could tolerate only 8 days of GIWW disruption before it would have to shut down. Oxy Chemical, which transports 150,000 barrels of goods on the waterway monthly, would have to close its facility within 15 days if it could not find another way to ship its goods.

d. South Padre Island. South Padre Island is a year-round beach resort that attracts more than two million visitors a year. Motel and hotel receipts totalled $27.8 million in 1989. Dunes in the area have been leveled for construction of high-rise hotels. Dune losses and erosion rates of 5 to 10 ft per year suggest an unstable coastal environment and the need for more erosion-conscious development practices.

DISCUSSION

Mr. John H. Lockhart, Jr. asked about mitigation banking. Ms. Davenport said they do not have that in Texas right now, but plan on examining that concept as they write their conservation plan. Louisiana, California, and some other states presently have mitigation banking. Many small mitigation projects in Texas have not succeeded for various reasons, and Texas is running out of sites for mitigation. The answer may be establishing mitigation on larger project areas, and they are going to be looking at that.

CORPS O&M DREDGING ACTIVITIES AND PROGRAMS TO REDUCE COASTAL EROSION

Dr. Linda L. Glenboski

Coastal land loss in Louisiana currently averages 31 square miles a year. Erosion is only one of many factors contributing to this land loss. Since 1974, the New Orleans District has been a major player in the effort to halt coastal erosion through the beneficial use of dredged material removed in routine maintenance of the Federal navigation channels.

Most of these beneficial use projects have been accomplished under existing project authorities. In these cases, the disposal alternative involving beneficial use of the dredged material for wetland creation or restoration was no more costly than alternative disposal schemes.

Special authorities, such as Section 150 of the Water Resources Development Act of 1976 and Section 1135 of the Water Resources Development Act of 1986, have been used for a number of projects when additional costs exceeded existing authorities.

Beneficial use projects are difficult and frustrating to implement because existing policy is unclear and inconsistent, and funding is limited. Corps of Engineers policy relative to the use of special authorities and the Operation and Maintenance (O&M) dredging Federal Standard procedure must be clarified so that the O&M Program can continue to restore and create wetlands and reduce coastal erosion in Louisiana.

DISCUSSION

Mr. Harley S. Winer asked how many tons of sediment are dredged from the Mississippi River channels in a year, and how much of that is used for marsh creation. Dr. Glenboski said she did not have the total available at the meeting, but a large percentage is used for marsh restoration and bank stabilization, and a smaller percentage is placed in disposal sites.

CORPS STUDIES UNDER WAY THAT ADDRESS COASTAL AND SHORELINE EROSION

Robert H. Schroeder, Jr.

Louisiana is losing over 30 square miles per year of its coastal marshes. This loss results from a myriad of causes - some natural, some man-induced. The New Orleans District is attacking that problem on several fronts. Existing projects through the Operation and Maintenance program are being utilized to create new marsh areas and to build bird islands. New construction projects emphasize the Corps' developing environmental engineering ethic. An example is the freshwater diversion program, whereby Mississippi River water is introduced to nourish coastal marshes and partially make up for the spring floods that have been precluded by construction of levees along the river. The recently dedicated Caernarvon Freshwater project is the first of the series to be constructed.

The most promising approach to reducing coastal land loss is the studies just beginning under the Coastal Wetlands Planning, Protection, and Restoration Act - commonly called the Breaux Bill. That legislation creates a Task Force, chaired by the Corps, with representation from the Department of Agriculture, Interior, and Commerce, the Environmental Protection Agency, and the State of Louisiana.

The Bill provides funds from the Sport Fish Restoration Account of the Aquatic Resources Trust Fund to support projects for coastal restoration. Of these funds, 70 percent would be used for projects in Louisiana, 15 percent for the other states, and 15 percent for the North American Waterfowl Plan.

The first effort of the Task Force will be to develop a list of priority projects. This list will contain only those projects which can be substantially completed in 5 years. Subsequent efforts will develop an overall plan for dealing with coastal erosion. The Bill provides for the program to be funded over 5 years with all funds to be expended over a 10-year period.

The program is cost shared on a 75-percent Federal, 25-percent local basis. The Bill further provides that the State of Louisiana prepare a Conservation Plan to achieve the goal of no net loss of wetlands as a result of developmental activities. When that plan is approved, the cost sharing reduces to 85 percent Federal, 15 percent non-Federal.

Of particular interest to the Corps of Engineers is the provision in the Bill that authorizes the Corps to carry out environmental projects and to give these projects equal consideration with projects relating to irrigation, navigation, or flood control.

The Bill provides the opportunity for all levels of government to work together to address a problem that is too great for any level to solve independently.

(No discussion after Mr. Schroeder's presentation.)

CHIEF'S CHARGE TO THE CERB

Over the past few years, the formats for our meetings have evolved to maximize the benefits of the counsel received from the Board. At the 48th meeting in Savannah, Ga, we implemented the theme format to narrow the scope of the meetings and allow the Board to concentrate on specific Corps mission areas or problems. This format has been effective and beneficial to our programs. After our last meeting in Fort Lauderdale, FL, General Kelly asked that the format be changed to further focus on specific issues related to the theme of the meeting. This would be accomplished by pairing a civilian and military member and having them take the lead in developing the Board's review and formulating recommendations on a specific issue. The members are to look at all aspects of the issue including technical and policy components. The members have received packages prior to the meeting containing the issues and additional background material. The meeting format has been structured so presentations will be made on the issues under consideration. At the conclusion of the presentations and discussions, the Board will meet in Executive Session to prepare a preliminary oral report on the issues. A written report will be prepared within 30 days.

I charge you to consider two issues:

a. Is technology adequate for calculating inundation, waves, coastal erosion, and storm surge due to hurricanes?

b. What R&D is needed to improve emergency operations during coastal flooding emergencies?

Because General Sobke is unable to attend, the first issue is assigned to three members, Professors Reid and Dalrymple and General Yankoupe. The second issue is assigned to Professor Raichlen and General Genega.

I will now turn the session on the hurricane issue over to Dr. Vincent.

PANEL
WAVES AND STORM SURGE DUE TO HURRICANES

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INTRODUCTION - CORPS USES OF HURRICANE INFORMATION

Dr. C. Linwood Vincent

The catastrophic results of a direct hurricane strike in a populated region are well known in the United States. In this century, about 10,000 hurricane-related deaths have been recorded in the United States (Table 1). The property damage from flooding and wind damage now usually tops $1 billion in a major storm. Considering that storm-tide levels have reached from 5-7 m at the shore and that deepwater significant wave heights exceed 14 m (extreme waves - 28 m), the power of a hurricane to inflict major death and destruction on a modern city remains, although the probability of such a strike for any individual city is low.

In recent years the death toll from major storms has been low. This has resulted from significant advances in storm tracking, prediction, and warning as well as emergency evacuation planning and public education. However, it should be noted that the extreme storms of the past 30 years have not struck major urban areas. A direct hit by a class 4 or 5 storm on the areas between West Palm Beach and Miami, from Fort Meyers to Tampa, New Orleans, Galveston-Houston, Norfolk, coastal New Jersey or New York City/Long Island, without adequate preparation/evacuation time, has the potential of a historic level of damage.

Foremost, the Corps of Engineers' mission related to hurricanes focuses upon protection from the storm-induced flooding and emergency operations afterwards. Hurricane surge and wave data are also required for dune, structure, harbor and beach-fill design. Increasingly more detailed prediction of storm conditions, flooding, and beach/dune erosion is needed for evaluation of project economics under the National Economic Development planning analysis. Corps of Engineers interest is typically in the analysis of historic storms or synthetic events rather than in the forecast problem.

Traditionally, Corps of Engineers interest in hurricanes has been focused upon US Atlantic and Gulf of Mexico coastal areas. However, hurricanes are important for Puerto Rico and the Virgin Islands. Typhoons in the Pacific are critical for coastal design in the US Trust Territories as well. The increasing population along the US coasts and vast property values involved lead to the question of whether the Corps of Engineers should become involved in research to develop innovative storm protection schemes or schemes that at least provide havens of refuge in areas that cannot be protected.

Table 1
Some Major Hurricanes

Site	Date	Death Toll
Galveston, Texas	1906	6,000
Florida/Alabama	1926	243
South Florida	1928	1,836
New England	1938	600
Dianne	1955	400
Audrey	1957	390
Camille	1969	256

RESEARCH NEEDS
HURRICANE SURGE AND WAVES
IN NEW ORLEANS DISTRICT

Adrian J. Combe

In the New Orleans District, the coastline stretches for 300 miles along the Gulf of Mexico, and the coastal zone includes 10,000 square miles of low-lying lands and marshes. In the city of New Orleans and the surrounding metropolitan area, 1.5 million people depend on the Corps of Engineers for hurricane protection. Dr. Neal Frank, past director of the Hurricane Center in Miami, often referred to New Orleans as a disaster site waiting for a hurricane. For the coast of Louisiana, we have developed seven hurricane protection projects. They are Lake Pontchartrain and Vicinity, Franklin and Vicinity, Morgan City and Vicinity, Larose to Golden Meadow, New Orleans to Venice, Grand Isle and Vicinity Beach Erosion Control and Hurricane Protection, and West Bank of the Mississippi River in Jefferson Parish. This last project was designed on a fast track. Part of the project is under construction and other parts are in feasibility or reconnaissance stages.

In the 1950's, the National Weather Service developed Standard Project Hurricane (SPH) windfields in a major effort for the Corps of Engineers. Since that time, the weather service has updated the SPH by a series of memoranda. Recently, the Coastal Engineering Research Center (CERC) has developed, under contract, a Planetary Boundary Layer model for hurricane windfields. Guidance from Headquarters, US Army Corps of Engineers, still indicates the use of SPH windfields. The New Orleans District (LMN) believes that a new initiative is needed to combine the expertise of the weather service and the Corps in this critical area. In the 1980's, the Committee on Tidal Hydraulics examined the available storm-surge models. They compared the results for six open-coast models and three inland-flooding models. The committee's conclusion was that the models gave equal results, but that each best applied to the coastal area for which they were developed. They further concluded that the primary need was for better data to verify the models.

Since that time, the Corps has continued to develop storm-surge models to the extent that CERC now maintains 19 storm-surge models and 13 wind-wave models. The LMN believes CERC needs to concentrate on fewer models of storm surge and wave hindcasting. Some of the older models must be excess to our needs. The LMN looks to CERC to help select those models that are inexpensive and easy to use without sacrificing accuracy. Better measurements of storm surge, waves, rainfall, windfields, and inland flooding are also needed to help the LMN develop economical hurricane protection projects. A new initiative is also needed to involve the National Weather Service in selecting the best criteria to define the hurricane parameters used for design.

DISCUSSION

Prof. Dalrymple asked about the elevations of the ring levees, and what consideration was given to sea level rise. Mr. Combe said the elevations of levees on the New Orleans lakefront are 14 to 16 ft, depending on foreshore slopes. If there is a stone revetment all the way up the slope, then you can have a lower elevation. The Mississippi River levees at New Orleans are about 25 ft. In Morgan City and vicinity, the design is 12 ft along the south side, and 9 ft along Lake Palourde. From Larose to Golden Meadow, the h ight is about 13 ft at the southern end and 9 ft at the northern end. Only the most recent project, West Jefferson, considered sea level rise.

Ms. Geneva P. Grille asked what agency was responsible for giving out, for example, a 100-year flood elevation or a Standard Project Hurricane elevation where you don't have a Federal project somewhere in the area. Mr. Combe indicated the Federal Emergency Management Agency (FEMA) had that responsibility. In some cases, the Corps does storm surge studies for FEMA, but FEMA has the ultimate authority.

Ms. Grille also asked about updating older information to account for coastal changes or new predictive models. Mr. Tickner noted that the Corps had entered into a Memorandum of Understanding with the State of Louisiana that gives them access to some of the Corps computer models.

Mr. Larry P. Bergeron urged the Corps to continue progress on providing the hurricane protection levee for Morgan City.

CORPS OF ENGINEERS PROCEDURES AND STATE OF THE ART IN MODELING HURRICANE EFFECTS (WIND PREDICTION)

Dr. Edward F. Thompson

Introduction

Hurricanes are critical design events for many areas of the United States coast, including the entire Gulf of Mexico coast. Along the Louisiana coast, hurricane-generated wind speeds have exceeded 190 miles per hour (mph). More than 100 tropical storms or hurricanes have impacted the Louisiana coast during the last 100 years. Although strong winds are damaging of themselves, they are also an essential driving force for waves, circulation, and storm surge in coastal and estuarine areas. Spatial wind-field information is a direct input to Corps of Engineers (CE) and other horizontally two-dimensional numerical models for wave growth, circulation, and storm surge. The input is usually a time-varying sequence of wind fields. The accuracy of results from these models is closely related to the capability for accurate representation of the driving winds. The objectives of this paper are to review present CE techniques for reconstructing hurricane wind fields and to highlight research needs.

Standard Project Hurricane and Probable Maximum Hurricane

One CE option for generating wind fields is the Standard Project Hurricane (SPH). The SPH model, developed by the National Weather Service (NWS), permits deterministic modeling of a suite of design hurricanes. It requires a few hurricane parameters including central pressure, peripheral pressure, radius of maximum winds, hurricane translational speed, hurricane direction, and inflow angle. At every US coastal location, NWS guidance explicitly specifies some parameters and provides ranges of values for others. The SPH represents the most severe combination of parameter values that is reasonably characteristic of a specific region, excluding extremely rare combinations.

Extremely severe hurricane wind fields can be modeled with the Probable Maximum Hurricane (PMH), also developed by the NWS. Parameters for the PMH are available as with the SPH. The PMH model has been used in designing nuclear power plants sited in coastal areas.

Planetary Boundary Layer Model

Planetary boundary layer (PBL) modeling provides another option for hurricane wind-field estimation. The PBL modeling approach is more comprehensive and flexible than the SPH. By this approach, the vertical structure of mean wind speed and direction is related to parameters such as elevation above the water surface, air-water temperature difference, and wind speed. The CE tropical storm PBL system of models was developed by Cardone, Pierson, and Ward (1976). Partial funding for model development came from the CE Wave Information Studies (WIS) hindcasting program, which generates oceanic scale surface wind fields from atmospheric pressure data. The PBL model system has been used heavily in WIS and in CE storm surge and wave project studies.

Coastal Modeling System

The SPH model is operational within the Coastal Modeling System (CMS), an integrated CE system of numerical models. Adaptation of the hurricane PBL model system to CMS is in progress. Models in CMS have common access to libraries of input, output, and other standardized routines. The system facilitates usage of numerical models and transfer of results from one model for use as input to another model. The CMS uses wind as an input in creating models for wave growth, storm surge, and circulation.

Hurricane Hugo Wind Fields

As part of a special effort to hindcast Hurricane Hugo, the PBL model system was recently used to generate wind fields (Tracy, Hubertz, and Payne 1991). High spatial resolution was achieved with nested grids, with the finest grid having 10-km cells. The nested grid was centered on the hurricane eye and its location was adjusted in time to follow the storm track. Wind fields were updated hourly. Wind estimates were compared with both land- and ocean-based measurements. Some limitations of the wind-field estimates are noted in the following section.

Research Needs

Research needs in hurricane wind modeling can be grouped into the general areas of: (a) processes over open water, and (b) interaction with land. In the first general area, field measurements, observations, and satellite photos over the last decade have shown that hurricanes can deviate significantly from the simple structure assumed by present models. Organized, nonsteady rainbands associated with intensified winds can be present. Double eye walls have been observed, giving two radii of maximum wind and an area of consistently high winds in between. Wind stress at the water surface due to hurricane winds is critical to wave and surge models, and better estimates are needed. Progress has been made recently in including the effect of steep, growing waves on local wind stress.

The second general area is hurricane wind-field modification in the vicinity of the land/water boundary. The Hurricane Hugo simulation illustrates limitations of present methods for modifying winds in land/water transition.

References

Cardone, V.J., Pierson, W.J., and Ward, E.G. 1976 (Apr). "Hindcasting the Directional Spectra of Hurricane-Generated Waves," Journal of Petroleum Technology, pp 385-394.

Tracy, B.A., Hubertz, J.M., and Payne, J.B. "The Effect of Hurricane Surge Levels on Nearshore Hindcast Wave Conditions - A Calculation for Hurricane Hugo," in preparation, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

DISCUSSION

Prof. Raichlen said it seemed it would be easier to understand the boundary layer over land rather than over water. Dr. Thompson said it is the transition going from water to land or land to water that is difficult. Prof. Raichlen asked about the possibility of modeling the boundary layer in a wind-wave flume. Dr. Thompson said that scaling would be a major concern in a laboratory facility, but he thought that it would be a fruitful thing to do. He mentioned that CERC has a work unit on wind modeling.

Prof. Reid said he thought that we should give further attention to quantifying wind stress, i.e., translating the PBL model. The PBL model has the capability of dealing with the wind profile and, therefore, the stress. Then you can add the feedback effect of waves influencing the wind stress. He noted that the work of Donovan in Canada shows there is a time transition period in the development of waves where the wind stress relation actually changes. Dr. Thompson said he agreed with that, and said that Mr. Butler would address wind stress.

Prof. Dalrymple asked what the state of the art was for nonparametric modeling, where you might develop a grid system and use full equations to predict the hurricane wind fields. Dr. Thompson said that the focus of research in that area has been in understanding processes and predicting hurricane tracks.

Prof. Dalrymple noted that, based on predictions for Hurricane Hugo, there was a 25-percent error in wind speed that would give double that error in stresses. That would create a problem in predicting surge.

Mr. Jesse A. Pfeiffer, Jr. suggested use of model maintenance money instead of R&D money for funding documentation.

CORPS OF ENGINEERS PROCEDURES AND STATE OF THE ART IN MODELING HURRICANE EFFECTS (STORM SURGE WATER LEVELS)

H. Lee Butler

In responding to the question on adequacy of technology for simulating storm surge processes, this section of the presentation focuses on the calculation of water levels during storms. A brief history of technical advancements and a listing of Corps applications are given, followed by a focus on an application to the New York Bight area, discussion of a "blind test" simulation of Hurricane Hugo, and a presentation of ongoing research and model advancement that may lead to a long-term answer to Corps needs in this technological area.

Historical Overview

An early method for determining open-coast storm surge was based on theoretical approximations of the governing equations by Freeman, Baer, and Jung (1957). This method is known as the Bathystrophic Storm Tide Theory and can be described as a quasi-static method in which a numerical solution is obtained by successively integrating wind stresses over the Continental Shelf from its seaward edge to the shore for a predetermined interval of time. A brief description of the method can be found in earlier versions of the Shore Protection Manual (1984).

In 1968, a 2-D model for embayments was presented by Reid and Bodine for the Galveston Bay area (Reid and Bodine 1968). Provisions were made in this model for simulating flooding and recession of low-lying terrain and the flow over subgrid scale barriers. Subsequent to these original model developments, many storm surge models have become available.

In the mid-1970's, an implicit finite-difference model was developed by Butler (1978) for application to tidal circulation problems in estuaries and was modified for application to storm surge simulation. The model is called the US Army Engineer Waterways Experiment Station (WES) Implicit Flooding Model (WIFM) and features treatment of inundation, subgrid barrier effects, and variable grid structure. Computation of surge effects gravitated from using the bathystrophic approach to using WIFM and other 2-D models.

In this same time frame, open-coast and embayment models (SPLASH and SLOSH) were developed by the National Oceanic and Atmospheric Administration (NOAA). These models were developed with the primary interest of forecasting surge-induced water levels for the purpose of providing evacuation data.

A study to compare these and other approaches was sponsored by the Committee on Tidal Hydraulics and results were published in 1980. Models used by the Corps, NOAA, and the Federal Emergency Management Agency were evaluated to answer three major questions relating to (a) further research and development needs, (b) significant disparities between stage-frequency relationships developed by Districts having common geographic boundaries, and (c) the cost-effectiveness of using a specific model. Several conclusions and recommendations were made and the reader is referred to Technical Bulletin No. 21, "Evaluation of Numerical Storm Surge Models" (Committee on Tidal Hydraulics 1980). Key recommendations included the need to acquire high quality data for model validation, research on the presurge anomaly in the Gulf of Mexico and on wind-field models, and improvement in techniques for storm frequency analysis.

From the mid-1970's to present, several applications of 2-D storm surge models have been made by the Coastal Engineering Research Center (CERC) as well as by individual Corps Districts. These include major studies for Galveston Bay, Lake Pontchartrain and the central Gulf Coast, Atchafalaya Bay, Florida Panhandle, Oregon Inlet and Pamlico Sound, New York Bight and New York Harbor, New England Coast, and the Hawaiian Islands, Guam, and Saipan in the Pacific.

All of the simulations discussed above were made using hurricane wind stress information from the well-established Standard Project Hurricane parametric wind-field model. The version of the model used in all simulations permitted a reduction of the open-water wind speed at the land-water interface and over the inland portion of the computational domain. All extratropical storms (appropriate for some of the studies) were modeled using historical wind information.

New York Bight Application

A study to investigate the frequency of storm-plus-tide flood levels along the coast and within the bays of southern Long Island, New York, was completed in the early 1980's. The approach adopted for estimating stage frequency due to storm-induced surge and wave effects involved conjunctive use of several models. The WIFM was used to simulate large-scale tidal and storm events over the entire New York Bight as well as nearshore and inland bay effects on a nested grid driven by output from the large-scale model. An ad hoc dune breach model permitted determination of dune overtopping and destruction. Several probability models were used to choose events to simulate, assign probabilities to those events, and construct the stage-frequency relationships according to the Joint Probability Method.

Nearly a thousand storms were simulated or results interpolated on the large-scale grid, and through a process of numerical convolution the tide effect was integrated into the problem, producing over a half-million possible surge-tide combinations from which a water level versus return period relationship can be deduced. A statistical "bootstrap" technique was used to estimate error in the frequency relationship by determining the variation possible in each component's probability distribution. This variability is due to the construction of the distribution from a usually small set of historical events.

For nearshore and inland bay results, it was necessary to represent the statistics of the extremely large set of storm-tide events on the open coast with a much smaller ensemble of events for simulation on the nearshore grid. For hurricane events, the selection procedure used resulted in a set of 51 storm-tide events, which were simulated on the inland grid and processed in a manner to yield confidence limits on the results. This procedure significantly reduced the computational effort to predict nearshore and inland bay stage frequencies without compromising result reliability.

The database of information created in the study discussed above has proven extremely valuable to studies conducted throughout the last decade to determine impacts of shore protection plans for large portions of the coasts of New Jersey and Long Island. Input from the database was used to develop sets of storms (for hurricanes and extratropical storms) and appropriate statistical information to feed a beach erosion model to evaluate existing and planned beach-fill configurations. The ability to determine recessional statistics enabled economists to estimate project benefits more accurately.

Hurricane Hugo

As part of a special effort to hindcast Hugo and provide a means of evaluating US Army Corps of Engineers storm surge modeling methodology, a "blind test" procedure was followed to model water levels from Hugo. A substantial quantity of data was collected for this storm, making such an evaluation possible.

As discussed earlier in this presentation session, a planetary boundary layer model was used for generating wind and atmospheric pressure fields. The WIFM model was applied on a stretched rectilinear grid which extended from Mayport, FL, to Cape Lookout, NC. The model was partially calibrated for tides by using tidal constituent forcing at the open boundary (from a global tidal model). The storm simulation was made by superimposing atmospheric pressure anomalies with the predicted tide at the open boundary. Various sensitivity tests were made to evaluate choices in model input parameters and wind-field representation.

A key conclusion of this study found that the greatest weakness was the model's inability to replicate peak surge levels within the radius to maximum winds and on the lee side of the storm. A priori choice of grid resolution, coarse in embayments, may have caused some of the erroneous results. However, most of the problems in the technology were attributed to the methods for wind-field representation.

New Model Advancements

All of the models discussed above have used the finite difference approach to solving the equations of motion. Other numerical methods have been tried but were not as successful as the primary storm surge models of major Federal agencies. A 2-D fully nonlinear finite element approach, based on solving the wave equation rather than the primitive equations, has now been formulated. Development of this new model was sponsored by the Dredging Research Program (DRP). Major advantages include ability to use a high degree of selective grid refinement, use of highly accurate and robust discretization techniques, and ability to achieve a concurrent high level of computational efficiency.

A proof of concept for using a large computational domain with grid refinement in nearshore areas was demonstrated by applying the model on the Gulf of Mexico to compute tidal and storm surge response. Typical grid spacing in the central gulf is on the order of 50 km with the smallest element in the nearshore area on the order of 300 m. Results of numerical computations for both tidal elevations and surge-plus-tide elevations compared very well with observed data.

The DRP is currently applying the model on a grid which encompasses the entire western North Atlantic continental shelf, the Gulf of Mexico, and the Caribbean. The actual purpose for this research is to: (a) develop a comprehensive database of tidal elevation and current harmonic constituents which can be used to reconstruct site-specific tidal forcings at discrete locations along the east coast and Gulf of Mexico, and (b) utilize tropical and extratropical global boundary conditions to compute frequency-indexed storm surge hydrographs along the US coasts. This database of storm and tidal information is being developed to provide site-specific hydrodynamic boundary conditions for use in analyzing the long-term stability of existing or proposed dredged material disposal sites.

These advancements have a variety of important advantages. First of all, the use of complex and highly variable cross-shelf boundary conditions is avoided. Secondly, the well-defined eastern open-ocean boundary condition can be driven using deep ocean results from global tidal models at a location where regional winds do not dramatically affect the sea surface. Finally, since the eastern boundary is well beyond the Continental Shelf, tidal boundary condition specification is valid with respect to the nonlinear component.

Research Needs

The significance of this research will be far-reaching. The coastal database and existing on-the-shelf model will provide sufficient information for project-specific analysis and preclude the need of generating complex, global grid surge models in the future. However, the problem of accurately simulating storm wind fields still exists, especially at the land-water interface. Additional research needs include improvements in statistical procedures to accurately predict not only flood frequencies but erosion rates and to accurately predict the current field caused by the storm for use in estimating sediment transport.

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DISCUSSION

Prof. Reid referred to the WES WIFM, and said he would like to compliment CERC for this recent new advancement with respect to a very detailed finite-difference, global-type grid. Mr. Butler said the basic intent was to probably produce three grids, one for the Gulf of Mexico, one for the South Atlantic coast of the United States, and one for the North Atlantic coast. The idea is to run storms and tides on these models. This work was pioneered by Professor Lynch at Dartmouth University, and has been carried on by several researchers in Europe. One of the people working on this with us has been Dr. Johannes Westerink, formerly with Texas A&M, and currently at Notre Dame.

Prof. Reid asked if there was any problem with continuity of mass in running the model. Mr. Butler said that the model is globally conservative, but may not be conservative cell by cell. That is a concern we have if we try to couple this model to other models, e. g., a water quality model that demands conservation of mass. That is an aspect being researched at the present time.

Prof. Dalrymple asked about bottom friction factors and frequency-indexed surge hydrographs. Mr. Butler said bottom friction is variable over the grid. With respect to the frequency, they intend to develop a database of a significant portion of the storms referred to by Dr. Vincent, and run those storms on the grid to develop a frequency.

CORPS OF ENGINEERS PROCEDURES AND STATE OF THE ART
IN MODELING HURRICANE EFFECTS
(WAVE PREDICTION)

Dr. Martin C. Miller

Introduction

Accurate, reliable wave data are required for designs of structures, shore protection measures, and other operations in the coastal zone. Records of measured wave data are available at a limited number of locations and for limited lengths of time. Very few measurements are available in locations where projects are planned. The Corps has, therefore, realized that wave information must be generated for specific sites by hindcast. In 1976, a program was begun at the US Army Engineer Waterways Experiment Station (WES) to hindcast 20 years of wave data along the coastline of the United States. This project has produced wave information for each 3-hr period for the years 1956 through 1975 on grids that cover the Atlantic, Pacific, and gulf coasts of the United States. Thirty-two years of hindcast information (1956 through 1987) have been generated for the Great Lakes. Additional efforts have gone into upgrading the accuracy of wave models, providing verification as measured data become available, and evaluating site-specific conditions such as island sheltering, current effects, refraction, and water level changes.

Descriptions of the wave field during hurricanes and tropical storms have presented special problems for the hindcast. Computer resources were limited and expensive at the outset of the project. The original calculations were, therefore, made on a deepwater grid spacing of 2 deg (120 nautical miles) which provided boundary condition data for a smaller (Phase II) grid of approximately 0.5 deg (30 nautical miles) spacing along the Continental Shelf. The deep ocean grid was too large to properly represent the hurricanes and tropical storms that occur along the Atlantic Coast. Additional model developments and verification were also necessary before hurricane wave conditions could be hindcast with confidence. These storms were hindcast separately from the rest of the 20-year record and are provided in a single report for the Atlantic and Gulf of Mexico.

Hurricane Hindcasts

A total of 68 storms, which occurred during the period 1956-1975, were hindcast. The proper representation of the wind field is a critical component of the hindcast of the hurricane. The planetary boundary layer (PBL) model of Cardone, reported on by Dr. Thompson, was chosen to calculate the wind fields since it allows the simulation of the asymmetry of the storm due to its forward motion. Measurements may also be blended into the wind fields if they are available. As pointed out by Vincent (1990), some elements of the wind field are not represented by the Cardone PBL model. These include the discrete band structure sometimes observed in storms, the front-like squall lines associated with anomalously high waves observed in Hurricane Edith (1971, Gulf of Mexico (GOM)), the double eye structure observed in Hurricane Alicia (1983, GOM), the interaction of storms with fronts, and the encounter of the storm with land. Garcia and Powell (1990) report that the radius to maximum wind, in Hurricane Hugo, was observed to contract from a distance of 60-80 km to 20-25 km, whereupon a secondary peak wind speed would sometimes form at a radius of 60-80 km. The inner maximum would be absorbed by the outer and the cycle repeated over a time of 12 to 24 hr. This cyclic, or "panting" behavior is not described by the wind models and its effect on wave generation is not understood.

The hurricane conditions were modeled using the spectral wave model, SHALWV, which was developed originally by Dr. Donald Resio, Offshore and Coastal Technologies, Inc., under contract to the Coastal Engineering Research Center (CERC). The model, which was extensively enhanced and expanded in its capabilities, including hurricane wave simulations (Jensen, Vincent, and Abel 1987). It has been verified with wave data for Hurricanes Camille, Frederick, Carmen, Edith, and Gloria, and for Tropical Storm Delia. It reproduced the general magnitude and characteristics of the waves observed without site-specific tuning. In individual cases, improvements in the simulations can be obtained by tuning the wind field or slightly altering the track of the storm within the known variability of these parameters.

Hurricane Hugo Simulation

Tests against Hurricane Hugo data were also made by the Wave Information Studies (WIS) group at WES's CERC using the present version of the WIS spectral wave model. This model also allows for the inclusion of surge by changing the water level over the grid as the storm progresses. Two National Oceanic and Atmospheric Administration (NOAA) wave buoys, which operated during the storm, provided data with which to compare the hindcast. One of these provided directional wave measurements. The wind fields used for the hindcast were prepared using the PBL model of Cardone. The wave hindcast was conducted using a nested grid, with the larger (0.5-deg spacing) providing the boundary condition for the smaller, nearshore grid spacing of 0.1 deg. The simulation allowed for changing water levels at hourly intervals so the waves could propagate and develop on the actual surge water level. The water level information was provided by the WES Implicit Flooding Model storm surge model, as explained previously. Comparison of the predicted wave height with the measurements showed that conditions were more accurately predicted to the right of the storm track (NOAA buoy 41002), though there were few times when measurement and hindcast agreed. The wave model consistently overpredicted the wave height on the left side of the storm (NOAA buoy 41008) and missed the peak in both amplitude and phase. The difficulty in this latter prediction is attributed, in large part, to the wind model, which does not accurately provide the winds as they exited from shore.

Present Research Activities

The CERC is a participant in the Surface WAve Dynamics Experiment, which was recently completed along the central east coast of the United States. The purpose of this large field study was to intensively sample the waves, currents, and winds over a relatively small section of ocean in order to provide data that will lead to improvements in the wave generation models.

Future Research Needs

Accurate wind fields are critical to the correct calculation of the waves and water levels. Particular problems are apparent on the left side of the trackline, after the storm has made landfall. A more accurate representation of the wind field would require that the problems pointed out by Vincent and others (above) be solved. Wave generation and propagation problems such as the effects of island sheltering and wave modification by large-scale currents are not unique to hurricanes and should be addressed. The storm surge time history was incorporated in the Hugo hindcast, and should be included in other hindcasts, as well. Verification of the hindcast skill requires high-resolution, directional, spectral wave measurements. Detailed measurements in storms of hurricane magnitude are difficult and may be expensive but are not beyond the state of the art. Measurements of waves using air-deployable, drifting wave buoys should be attempted and remote sensing methods for winds, waves, and other important storm parameters should be developed. The results obtained from moored buoys are useful but are frequently too far from the storm to provide details of the wave generation. Nearer the storm, measurements from moored buoys tend to be suspect since mooring stresses and motions may affect their accuracy.

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DISCUSSION

Prof. Raichlen asked if the waves in the hurricane system are highly three-dimensional, and do the wave hindcast models really apply to those types of waves. Dr. Miller said the waves are three-dimensional and are affected by the rapidly turning winds. That is an area that will be looked at more carefully. The storms have a moving fetch area generating fetch-limited waves, and that complicates the determination of the wave heights.

Prof. Dalrymple noted that there is a wave effect on bottom friction as seen in the surge model. He suggested that as an area to look into in the future.

CORPS OF ENGINEERS PROCEDURES AND STATE OF THE ART IN MODELING HURRICANE EFFECTS (BEACH MODIFICATION)

Dr. Nicholas C. Kraus

Reliable estimation of the level of protection required for hurricane and storm protection projects is a major factor for achieving proper design and performing an accurate cost-benefit analysis. Human life and valuable resources are at stake in these projects. Dramatic examples are numerous: the 8 September 1900 hurricane that impacted Galveston Island, TX, (which followed a hurricane in 1895 that had also caused serious damage) destroyed 3,000 homes with a 15-ft surge in which approximately 6,000 people perished. A 21 September 1938 hurricane with a surge of 9 to 11 ft that struck the east shore of Long Island, NY, is the storm of record for the area, and 90 lives were lost. The period 1938 to 1962 was one of marked erosive storm activity for the New Jersey and New York coasts and includes the 1938 hurricane, 1944 hurricane (for which the Standard Project Hurricane methodology was originally developed), 1950 and 1953 northeasters, 1954 and 1960 hurricanes, and the infamous 5-8 March 1962 Ash Wednesday Storm, a northeaster, which stalled off the coast of New Jersey for a period spanning five high tides, hence its nickname of the "5-high" storm. Recently, the 22 September 1989 Hurricane Hugo devastated several barrier islands along the South Carolina coast.

Hurricane protection design has traditionally involved prediction of several meteorological and hydrodynamic phenomena, principally wind, waves, and surge. In the past decade, numerical models of storm erosion and beach profile change have become available that have supplanted more empirical estimation procedures and greatly improved predictive capability. One of these models was developed at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station, over the period 1988 to 1989 and is called SBEACH, standing for the Storm-induced BEAch CHange model. Requests for release of this model by Corps of Engineers Districts have been numerous and reflect a great need for such a modeling technology; guidance from Headquarters of the Corps of Engineers requires use of this model, where practicable, in design of shore protection beach-fill projects. This presentation will provide an overview of the newly developed SBEACH model and indicate areas of ongoing and planned research in storm erosion modeling.

Techniques to estimate storm-induced beach erosion may be classified into three general types:

a. Simple empirical methods.

b. Morphologic numerical modeling.

c. First-principles numerical modeling.

Simple empirical methods include rules of thumb based on field data that typically estimate the maximum erosion potential of a given storm. Other empirical methods involve an assumption of an equilibrium profile form and translation and transformation of this form according to certain rules. One such method was developed in The Netherlands for extreme surge based on extensive large-scale physical model tests. Besides having the weakness of calculating the potential erosion that may not be reached in a given storm, empirical procedures are insensitive to the actual initial dune, berm, and beach profile shape, which may not be in accord with the idealized assumed shape.

Morphologic numerical modeling is a phrase associated with development of SBEACH. The underlying principle stems from the observation that large-scale beach change follows regular patterns depending on the wave conditions and initial beach profile shape. For example, longshore bars tend to form under steep waves and berms tend to form under mild waves. These general beach morphologies persistently occur under extraordinarily complex hydrodynamic and sediment transport conditions that are to a great extent random. Therefore, a critical first phase in the SBEACH development process was to study and quantify beach profile change that has been measured in large-scale laboratory tests and in the field. By the same procedure, empirically derived predictive relationships for the net cross-shore transport rate were derived, and four distinct transport regions were identified along the beach profile; foreshore, surf zone, pre-breaking wave zone, and the area seaward of the breaking zone.

In addition to dune and beach erosion, SBEACH simulates (in a time-dependent calculation) the development and movement of longshore bars. Therefore, it can calculate beach erosion according to actual hydrodynamic characteristics of the storm (surge and wave height and period time histories) and not just the maximum potential erosion. One of its capabilities is simulation of recovery processes, including berm development, although the description of recovery processes is not yet complete owing, in part, to the absence of data. This means that the model can account for beach recovery in the situation of successive storms. More realistic calculations allow development of proper beach-fill designs as well as allowing more accurate cost-benefit analyses to be made. The SBEACH has undergone considerable testing; nevertheless, research and technology transfer need to be done before this emerging technology can be considered as mature.

First-principles numerical modeling implies calculation of time-dependent sediment transport rates from fundamental formulas that incorporate details of the flow (such as higher order moments of velocities, vertical structure of the velocity field, short and long-period waves) and sediment motion (sheet flow, bed load, and suspended load). Some success has been achieved with such models, but information on the capabilities and limitations of these proprietary models is limited. One problem is availability of appropriate high-quality data sets with which to develop and test such detailed models.

To fill the data gap that exists for developing and refining all categories of beach change predictive models, in July and August 1991, research work units of the Coastal Program at CERC are joining with work units of the Dredging Research Program (DRP) to conduct a major laboratory data collection project using the large wave tank located at Oregon State University. The SUPERTANK data collection project will include approximately 15 current meters, 12 wave gages, 25 suspended sediment optical gages, 2 suspended sediment acoustic gages, 1 laser-doppler velocimeter for boundary layer measurements, and numerous other instruments and more traditional procedures such as sand tracers. The SUPERTANK is without a doubt the most heavily instrumented experiment ever performed on cross-shore sand transport and beach profile change. Research needs are great in the area of storm erosion and beach profile change. The hydrodynamics of the surf zone are not well understood. Sediment transport relations are lacking. Sediment transport at the critical beach - water interface at the shore is particularly obscure. In addition to these and many other fundamental problems, the translation of any developments to the arena of engineering use must be made.

For example, even if sediment transport could be predicted accurately from knowledge of the detailed fluid flow, such information is certainly not available in engineering projects.

The next decade will be one of remarkable progress in storm erosion modeling. The existing SBEACH model will provide much guidance on how to proceed to obtain maximum benefit of limited resources. At the same time, research will be initiated to attack the problem by a fundamental microscale approach as well as to continue refinement of the morphologic approach. The dual microscale and macroscale research efforts will complement each other in solving major problems for improved predictive capability in the future, while providing Corps users with reliable technology today.

Finally, it is pointed out that existing storm erosion models, including SBEACH, are two-dimensional models that compute beach profile change under the assumption that cross-shore sediment transport processes are dominant. This assumption is equivalent to a model in which longshore gradients in sediment transport are constant. Work is now underway to develop a three-dimensional (3-D) model of sediment transport and beach change that removes this restriction. The model has tentatively been named 3DBEACH for "3-D Decoupled model of BEAch CHange," and the strategy followed is to compute longshore and cross-shore transport independently (decoupling). Decoupling vastly reduces computation time as compared to "point" or "box" models, yet allows many processes to be more easily represented than point models from the morphologic perspective. The model will have applicability to beach segments in the vicinity of structures and to features such as finite-length artificial bars placed offshore in connection with beneficial uses of dredged material. A skeleton version of such a model has been developed and tested at CERC. In the next 2 years, work units of both the Coastal Program and the DRP will go forward in development of this model.

DISCUSSION

Prof. Reid said he would certainly endorse the possibility of going to 3-D effects in future research and, in particular, would come back to the effect of surge. An additional effect of surge is that you have accompanying longshore currents, and the longshore currents are much greater than any transverse current. The primary transverse currents are those associated with the waves. Tr longshore current associated with the surge will have a convergence of longshore flow and, therefore, a convergence of the possible transport. This could represent a significant contribution to the scour or accretion depending on the size of the divergence or convergence of longshore sediment transport. Prof. Reid also noted that an additional effect to local wind producing tide level nearshore is wave setup that is above and beyond the runup of the transient effect of the wave. In addition, because of the radiation stress, you have a wave setup, which is possibly a steady effect. Dr. Kraus said that the SBEACH model includes the radiation stress and wave-induced setup, and does that over a large, arbitrary profile. He said he would send Prof. Reid the NMLONG Program for his inspection.

Prof. Raichlen noted that the SBEACH model was being compared to laboratory studies conducted in large wave tanks, and that there would be some reflection from the wave generator. He asked what compensations would be made to account for that. Dr. Kraus said that previous experiments had shown about a 10-percent reflection. For the SUPERTANK experiment, Oregon State University was required to install a reflection-compensating tidal system. This is being tested, and is intended to absorb the waves. Ms. Jane Smith said that the system was installed, and was being tested.

Prof. Dalrymple asked if beach recovery was included in foreshore processes, a first priority of research needs. Dr. Kraus said that it was. Prof. Dalrymple also urged CERC to put greater emphasis on 3-D modeling because of the nature of the problems, primarily in planning, with inlets, for example, or beach fill operations. He said we have come some distance in understanding 3-D hydrodynamics, but there is a great deal of knowledge that we need to acquire in terms of sediment transport. He is not sure that it is within our capabilities at the present time to fully run a 3-D model, but he thinks we have to start.

Mr. Joseph Raoul, Jr. asked about interaction with other agencies and other countries. Dr. Kraus noted that in the Workshop scheduled in conjunction with Coastal Sediments '91, there would be a Dutch speaker presenting the state of the art of Dutch modeling. One of the two conference sessions on cross-shore sediment transport was organized by the Dutch. A lot of the Dutch data are proprietary, and precludes cooperation in those cases. Dr. Kraus said the Dutch work is ramping down because they have satisfied a lot of their needs. He added that there is other cooperation with the Japanese and with the University of Lund in Sweden.

Mr. Pfeiffer asked if there would be any 3-D effects considered in the SUPERTANK experiment. Dr. Kraus said that they would be using a 12-ft wide by 15-ft deep tank. They will be looking at vertical effects, and the longshore is assumed uniform.

BG Genega asked about the release date for SBEACH. Dr. Kraus said that two reports have been published, and a tutorial has been written. A beta version (test copy) of the program has been sent out, and District people have been testing it. Some good comments have been incorporated, but the documentation and testing are not quite complete. The model is available now for District use, with certain guidance, and will be released in approximately a year.

Mr. Holliday asked about the innovative data collection that had been mentioned. Dr. Kraus said the person taking the data had an intimate knowledge of the needs, and had a wave gage and tide gage at the site because of a particular project. When he saw a storm coming, he organized, with the contractor, various procedures for that contractor to change the schedule of routine profiling and to remain onsite for the duration of the storm, and come back as soon as the storm subsided. Actually, they were doing profiling during the storm.

SUMMARY OF CAPABILITIES AND RESEARCH REQUIREMENTS

Dr. C. Linwood Vincent

The Corps of Engineers activities in the first 60 years of the century were instrumental in developing and implementing major storm-protection projects in the United States. Many of the initial attempts at surge and wave modeling from hurricanes grew out of the needs of the Corps of Engineers. The four preceding papers have amply illustrated the capabilities of existing models to simulate winds, waves, surges, and beach response. In many cases, the quality of the simulations far exceeds what the original pioneers in the area of research may have thought possible. Nonetheless, in each area the models demonstrate inaccuracies and weaknesses that require improvement.

The first area of research must be an increase in the ability to accurately describe the hurricane wind field, especially in its spatial detail, when the storm interacts with land. The coupling via a drag law between wind model and wave and flow models remains an area of interest. Increased computational speed allows better treatment of the surge, and it is hoped that improvements can be achieved in predicting current speeds. The beach and dune erosion models are being extended to three-dimensional modes. In the wave prediction area, the need is for better data to evaluate the models so that future research directions can be decided. In all areas, the need for improved field data for model validation remains a major issue.

In the longer term, a research decision must be made as to whether to continue in the current mode, which involves development of independent, uncoupled models. Near the shoreline and in the area of inundation, the physical processes probably become highly coupled, particularly in terms of predicting eroding of a storm dune, wave run-up, and overtopping into previously dry areas. However, it is not clear that the costs of developing these models are currently justified or that the current level of technology can support such a study.

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CORPS AUTHORITY/ROLE IN DISASTER RESPONSE

Gary M. Campbell

Discussion Points on Corps Readiness and Response Programs
from
NBSC Teleconference on Emergency Response and Communications

1. The primary mission of the Corps of Engineers is to meet the needs of the American public in time of crisis, whatever the cause.

2. The crisis could be the result of a natural event, technological accident, domestic unrest, or threat to our national security.

3. The Corps is a part of the Department of Army/Department of Defense/Federal agencies team that supplements the efforts of state and local interests to respond to and mitigate the effects of the crisis. Some crises, particularly those related to national security, become a Federal team lead responsibility.

4. Crises in which the Corps has provided assistance under its authorities or in support of other agencies, include: floods, tornadoes, hurricanes, typhoons, earthquakes, explosions, oil spills, hazardous material spills, volcanic eruptions, droughts, contaminated water supplies, mobilization of armed forces, restoration of essential services following armed conflict, reconstruction of war-damaged areas, and domestic emergencies such as strikes.

5. In most flood situations, both inland and coastal, the Corps is the primary Federal agency responsible for providing support to state and local emergency response efforts. During recovery, the Corps executes missions under its own authorities and in support of other agencies under their authorities.

6. To be prepared to undertake the multitude of support missions that may evolve during a crisis, the Corps uses what is described as a "Readiness Management Cycle." The steps in the cycle include:

   a. Development of policy and plans with related training of response individuals.

   b. The exercising of such plans and policies or their use in response to an actual crisis.

c. Evaluation of what occurred during the exercise or actual event.

d. The identification of corrective actions to pursue under the policy and plans part of the continuing cycle.

This cycle allows for constant enhancement of the ability to respond to identified crises and to address new contingencies as they evolve.

7. The Corps of Engineers has been in the business of meeting the needs of the nation in time of crisis since its inception. Initial missions were to support the needs of the Continental Army during the Revolutionary War. The role of the Corps in meeting many new needs of the nation has grown over the years, particularly in the Civil Works Program. Concurrently, the responsibility to be ready to meet the special needs brought on by a crisis has expanded. The Corps executes its missions as part of a Federal agency team. While there have been multi-agency plans to meet the needs of specific crises, recently the Federal family developed a plan to address a multitude of crises under which the Federal government would be expected to provide assistance. The Corps is proud to be one of the 27 agencies involved in the ongoing development of the Federal Response Plan. Planning efforts are proceeding to ensure the Corps' ability to execute its responsibilities as one of the 12 primary agencies.

Questions and Answers

1. Under what authority does the Corps of Engineers accomplish its emergency missions? The Corps' primary authority for providing emergency assistance to state and local interests is Public Law 84-99. It is intended to deal with floods and coastal storms. It also provides authority to develop contingency plans for response to all natural disasters under the Corps' authority or in support of other agencies. Civil Works projects are also operated to minimize the impacts of various disasters.

2. How does the Corps support other Federal agencies? When requested by another agency which has authority to provide assistance or execute emergency operations, the Corps can provide its expertise on a reimbursable basis to ensure rapid execution of required assistance. Such assistance has included general damage assessment, inspection of damaged structures, emergency restoration of essential facilities, restoration of infrastructures, technical advice, provision of available equipment, use of Corps facilities in support operations, and others.

3. What is the Corps' involvement in the Federal Response Plan? The Corps is one of 27 agencies involved in the development of the Federal Response Plan. As one of the 12 primary agencies, the Corps is designated as lead and is responsible to ensure that all necessary planning is accomplished for the Emergency Support Function (ESF) No. 3, "Public Works and Engineering." This includes the efforts of those other agencies designated to support the Corps' efforts. In addition, the Corps is designated as a support agency to 8 of the 11 ESFs.

4. What allows the Corps to be effective in providing emergency assistance in time of crisis? While there are numerous reasons that could be stated, the primary ones are:

   a. A large (40,000+) pool of multi-talented professionals that includes engineers, scientists, contract specialists, construction managers/inspectors, planners, environmental specialists, natural and other resource experts, logisticians, real estate specialists, and related support personnel.

   b. A widely dispersed organizational structure, with major headquarters and/or multiple area/project offices in every state except Rhode Island.

c. A centralized development policy and planning guidance for consistency but with decentralized and delegated authority to execute emergency response.

d. A primary Corps mission is to be ready to respond effectively to any contingency that could threaten or adversely affect the American public and the security of this nation.

5. What type of assistance has the Corps been involved in recently? We have been involved in numerous disasters since 1988, both under our authorities and in support of other agencies, primarily the Federal Emergency Management Agency (FEMA). Some of the events were:

a. The major drought that affected a large part of the country in 1988/1989 and continues in some areas even today (Pacific Southwest). The Corps is involved in maintaining water supplies and water quality for major urban areas, keeping the inland navigation system operational, ensuring water quality on major rivers, and providing water for human and livestock consumption.

b. The record flooding in eastern Texas and southeast Kentucky in early 1989. Corps activities included flood fight assistance and repair of damaged flood control works.

c. The EXXON VALDEZ oil spill in Alaska in 1989. The Corps gave technical advice and used hopper dredges to collect oil on the open sea.

d. Hurricane Hugo in the Virgin Islands, Puerto Rico, South and North Carolina. Corps response and recovery operations included construction of temporary beach dunes, transport of drinking water, debris removal, and restoration of critical access. In the Virgin Islands, the Corps was tasked by FEMA to oversee the restoration of the Island of St. Croix's infrastructure, public housing, and provision of temporary shelter. Part of that effort continues today. At the peak, there were over 1,000 Corps employees involved.

e. The Loma Prieta Earthquake. The Corps provided both individual and public assistance under FEMA. On the Friday evening after the earthquake, the Corps was tasked to have an additional 300 technical experts on site by Monday, and was able to fully meet that need from across the United States. At the peak, nearly 900 Corps personnel were involved in the response and recovery effort.

f. In 1990, the Corps responded to major record flooding over southeast Oklahoma, eastern Texas, Louisiana, Mississippi, southern Alabama, the Florida Panhandle, southeast Ohio, Indiana, Iowa, and western Washington. Supplemental actions to support state and local flood-fight efforts included providing materials and equipment, undertaking actual operations, and offering technical advice. The Corps has repaired, and continues to repair, damaged flood control works.

g. Some of the flood problems in 1990 have continued into 1991, and the United States has experienced some of the highest stages in parts of the Ohio, Tennessee and the lower Mississippi River basins in the last 20 years. The Corps continues to supplement state and local flood-fight efforts, where required, and to monitor conditions across all threatened areas.

FEMA AUTHORITY/ROLE IN DISASTER RESPONSE

Robert P. Fletcher

A philosophical transition has occurred within the Federal Emergency Management Agency (FEMA) and within Federal Emergency Planning Agencies, including the Corps of Engineers. The Federal government is going to take a more active role in the response to catastrophic events. The Corps of Engineers is one of the few agencies that has statutory authority to be able to respond quickly and be on the scene providing assistance.

Other agencies are more attuned to recovery operations. The FEMA has traditionally been mandated to be a recovery-oriented agency. Once individuals, communities, counties, and states have had their capabilities surpassed, the Federal government comes in under a Presidential Disaster Declaration and provides Federal assistance, usually on a cost-sharing basis, to provide for the unmet needs.

There normally has been a period of time between the occurrence of an incident and the time recovery efforts start. Using Hurricane Hugo as an example, MG Robert M. Bunker, former Commander of the Corps South Atlantic Division, was ready to roll with contracting capability but was delayed because the mechanisms of government had to unfold. The appropriate taskings had to be given from FEMA.

The FEMA is trying to cut that delay by allowing agencies to respond directly in times of crises. The FEMA, at the urging of Congress, some Federal agencies, and the General Accounting Office (GAO), is to reorganize within its state and local programs and support directorate, and create a new office. That new office is called the Federal Response Division. Under that Division, there is planning for catastrophic disasters and Federal response of the 27 Federal agencies that are coordinated within that response. There are all-hazards exercise planning, and then the analysis and corrective-action type activities that go with measuring how well you do in a real-world event, or an exercise in trying to fix things when an event is over, not unlike what the Corps of Engineers does.

The Federal Response Plan is primarily oriented to delivery of assistance under the Disaster Relief Act, Public Law 100-707, which amended Public Law

93-288. This Act also provides for the President's Disaster Relief Fund through which many of the response and recovery activities are funded. When signed, this plan will become the operative guidance for all Federal response planning under the Disaster Relief Act.

The plan will also provide a framework through which we will respond to other things, such as the Federal Radiological Emergency Response Plan for nuclear power plant accidents, the National Contingency Plan for oil and hazardous materials spills, and the program that deals with chemical stockpiles. This plan will provide the framework through which all Federal agencies will plan to respond for consequence management.

An Emergency Support Function (ESF) is a grouping of types of assistance that are similar in nature, that state and local governments most frequently request in a catastrophic emergency. After the activities and services were grouped, they fell into 12 convenient categories and, then, cognizant agencies were put in charge of those ESF's. It made sense to put the Corps of Engineers in charge of public works and engineering. The primary agency facilitates the planning for that emergency support function with the support agencies that are under it.

The plan will work better than things have worked in the past because there is a provision for emergency response teams (ERT). These would be multi-agency teams comprised of personnel from agencies most likely to be involved in the early response to the disaster. The ERT deploys from their home agencies to the state emergency operations center, and then into the disaster field office, once it's established. The ERT provides the necessary liaison between the state that is requesting the assistance and the Federal government, who is providing the assistance.

The ERT performs the initial situation assessment in cooperation with the state government. If immediate disaster assistance is needed, the Federal agencies having responsibility can proceed immediately to provide that assistance. There is a provision for the President to declare a major disaster or emergency. It has been demonstrated that such a declaration can be made in a matter of hours if it is determined a catastrophic emergency has occurred.

The ERT can move out in advance of the declaration of emergency, with the assumption that FEMA will reimburse their efforts whether or not there is a declaration. The advance ERT will meet with the state upon identification of the disaster. If it is determined that Federal response is not required, the ERT can return home, however, they will be onsite ready to respond if a response is required.

The ERT provides for logistics, provides operations, and even provides preliminary setup for recovery operations, recognizing that response and recovery are initiated simultaneously. "Response" means when the Corps goes out to get the job done, and "recovery" starts when someone asks who authorized the assistance and who is going to pay for it. Response is on a critical time scale when lifesaving missions are required, and recovery is on a more flexible time scale after critical missions have been accomplished.

The response operations have the ESF's mentioned. As part of that, they provide liaison from their agencies, with the state counterparts, and facilitate the smooth transition of requirements from the state into the Federal agencies. The ESF's are the essence of why this plan will work.

The regional operations center is an Emergency Operation Center (EOC) at the FEMA region. That will be activated immediately upon an incident occurring, and will be the command and control center until such time as the disaster field office is set up when the Federal coordinating officer joins the team. The Federal coordinating officer represents the President on the scene. Provisions for public information, Congressional liaison, community liaison, and outreach are also added to that baseline organization.

At the national level, the President is in charge of the authorization for a disaster declaration, with the Director of FEMA at his side. The Chairman and Associate Director of State and Local Programs Support head up a body called the Catastrophic Disaster Response Group (CDRG). In the early hours following the Loma Prieta earthquake, the CDRG was convened at FEMA. There were representatives of 27 Federal agencies on a conference call with the State of California and its counterpart agencies in Sacramento. Before midnight on the day of the earthquake, the Federal agencies were prepared to move to assist the state. This policy forum worked so well that it was adopted and will be used on all catastrophic disasters in the future.

There is an Emergency Support Team (EST) that supports the CDRG. The EST is the people who stay behind to support FEMA and their agencies as a collective liaison body between FEMA and the other Federal agencies after the CDRG is convened. The headquarters level EST will be an organization that operates around the clock in three 8-hr shifts. There will be a dedicated logistics support element. The information and planning element is a critical element that is going to serve all the Federal agencies as well as collect information from Federal agencies. There is a finance element for collecting estimates from Federal agencies on whether supplemental appropriations will be needed in a catastrophic emergency to be able to support all the activities that are under way.

To show how this works, upon the occurrence of a significant disaster, perhaps a category 4 or 5 hurricane, a declaration will be made and the FEMA Director will implement the provisions of the plan. The regional operations center will be activated, and the ERT will deploy by ground, or by air to the closest available airport, to go to the state EOC. The ERT will join the state emergency operations team and, upon establishment of the disaster field office, will go into the affected area.

In the case of a hurricane, where there is adequate warning, there will be a predeployment of the ERT to the state EOC in advance of the hurricane landfall. Because hurricanes are unpredictable, there may be three or more ERTs deployed to state EOCs. The ERTs will be operational immediately following the storm, and will deploy into the disaster area itself as the hurricane moves offshore or moves inland. Mobilization Centers will be established to receive equipment and services that are coming into the area, but are not ready to be staged into the disaster area itself. The disaster field office will be established as a one-stop shopping center for state and Federal assistance to the disaster area. The state EOC will continue to operate until it is deemed appropriate to move the ERTs to the disaster field office. Some states feel they need to keep the EOC open in support of the governor.

The requirements will flow from the communities in the disaster area to the state. The state will set priorities and allocations on those requirements, and pass the requirements to the Federal side. The Federal agencies will deploy assets from the mobilization centers into the staging area and then provide that assistance to the communities.

In at least some parts of FEMA, the Readiness Management Cycle is being adopted. That is basically a very simplistic cycle that talks about preparedness, execution, evaluation, and corrective action. There will be an exercise of the Federal Response Plan in August 1991, using a New Madrid earthquake scenario. This will involve seven states, four Federal regions, and Headquarters, US Army Corps of Engineers. It will run concurrently for 4 days, from 12 locations, on a catastrophic earthquake scenario.

The purpose and objective of that exercise is to test the interagency liaison (the linkup between state and Federal government) in a catastropic disaster event. The FEMA expects follow-on Federal exercises. In 1992, there will be a full-field exercise in the New Madrid seismic zone. The Federal Response Plan for that particular threat will be tested.

R&D NEEDS IDENTIFIED FROM HURRICANE HUGO AND OTHER DISASTERS

Thomas W. Richardson

Hurricane Hugo was sufficiently powerful and destructive to catalyze a number of investigations into its characteristics and coastal effects, and their relationship to the existing state of knowledge. Although many of these investigations were conducted relatively independently, several efforts have been made to develop post-facto consensus recommendations based on the study results. One of the more comprehensive of these efforts was carried out under the joint sponsorship of the American Shore and Beach Preservation Association (ASBPA), the Corps of Engineers, and the South Carolina and Florida Sea Grant Programs in a three-part approach. The first part comprised an invited workshop held at Folly Beach, SC, on 21-22 May 1990. Participants in the workshop presented reviews of their work and took part in panel discussions on several general topics. Agencies and organizations represented included the National Oceanic and Atmospheric Administration (NOAA), the Corps of Engineers, the US Geological Survey, the University of Florida, the South Carolina Coastal Council, Coastal Science and Engineering, Inc., the American Society of Civil Engineers, Purdue University, North Carolina State University, and the ASBPA. The second part of this approach was the publication of "white papers" by the workshop participants on specific coastal aspects of Hugo in an October 1990, special edition of the ASBPA Journal, Shore & Beach. The final part was a 1-day open conference held in conjunction with the Fourth Annual Beach Preservation Technology Conference in Charleston, SC, 27 February - 1 March 1991.

This presentation will summarize consensus recommendations developed through the three-part approach outlined above, and will also discuss results, to date, of an initiative to produce better coordination among Federal agencies involved in tropical storm coastal data acquisition. The first step in this initiative took place in a workshop at the South Atlantic Division in Atlanta, GA, on 16-17 April 1991. Representatives from 11 organizations met to discuss tropical storm mission roles and data collection activities, and to develop the initial form of a plan for better coordination. One week later, a similar workshop sponsored by the South Carolina Sea Grant Consortium produced an analogous coordination initiative at the regional state level that is now proceeding in concert with the Federal effort.

ONGOING RESEARCH AND DEVELOPMENT EFFORTS

Frank E. Stubbs

Geophones

One of the obvious problems in urban search and rescue lies in the determination of whether there are survivors in downed buildings where access is not possible. The use of geophones, or transducers, to detect noise caused by survivors beneath the rubble is proving to be considerably valuable. Israel and France have been using this system for some time now and have used it in large-scale disasters around the world.

The US Army Engineer Waterways Experiment Station (WES) has developed a geophone prototype, which is a metal box about the size of a doctor's bag and has a headset for listening and several frequency and filter dials. It also has numerous transducers, which receive vibration and sound waves from solid materials and amplifies them into sounds and electronic signals, which are sent to the headset and cassette recorder on the geophone.

Expedient Flood Fighting Techniques

During high river stages, when the predicted maximum water levels encroach on or exceed the design freeboard of existing levees, it must be determined whether or not to construct a temporary levee-raising structure, and, if so, the type to be used. Although temporary structures, such as mud boxes, flashboards, sandbags, and potato ridges have been used as emergency measures along thousands of feet of levees in times of flooding, there are no documented load conditions for which the structures are assured to work. Many concepts are completely untried. During flooding, these expedient levee-raising structures have and will continue to require vast amounts of funds. They also will be expected to protect residential and commercial property and the individuals inhabiting these areas. Because of the possibility of catastrophic occurrences in the event of a structural failure, acquisition of data relative to expected performances during defined static (differential heads) and dynamic (wave attack) loadings is necessary.

The WES was given the special project of evaluating some tried, but not always proven, flood fight techniques. The purpose of the model study was to define the static and dynamic load limits beyond which selected existing (Corps) designs of expedient levee-raising structures will fail. Besides the existing designs, new concepts submitted by various Divisions and Districts were considered for testing as time and funding allowed. Based on test results, recommendations for needed design improvements were made.

The Corps is now looking at some additional studies on this subject. Upon completion of this study, the WES will be asked to publish an Expedient Flood Fight Manual.

DISCUSSION

Dr. Camfield noted that a new international journal that reaches a rather diverse audience is the Journal of Natural Hazards. He encouraged Mr. Stubbs to get some of the information he had presented published in the journal. Mr. Campbell said that is an item that came out of the subcommittee. They are looking at how to feed information into the UN's International Decade Subcommittee on things that the US is doing. But it needs to be in a format that, particularly, these third world and developing nations can use. He also noted that they were trying to validate all the techniques they undertake so that when they are put in a manual they have been validated as workable.

POTENTIAL R&D NEEDS

Gary M. Campbell

The Corps of Engineers has funded some specific Research and Development (R&D) that applied existing efforts and technologies to meeting the Corps' responsibilities in response to emergencies. The basic purpose of the field review group (FRG) being established is to identify the requirements from the field in various arenas. This FRG is not just emergency management people. It involves everyone from engineering, construction, and other areas that have to meet the missions noted earlier.

One item now being used is the Cold Regions Research and Engineering Laboratory's (CRREL's) satellite imagery analysis. It has proven itself relative to offshore oil spill tracking, and a mechanism has been set up with CRREL and the Topographic Engineering Center to try to get that real time. The Corps proved this out in its involvement with the Persian Gulf oil spill.

Another arena of heavy involvement with CRREL is ice engineering. Field people have been advised not to execute response to ice jam problems without consulting CRREL, because CRREL has the expertise on that. The R&D community is an integral part of dealing with the disaster.

One area the Corps needs to look at further is utilization of satellite imagery analysis and the Geographic Information Systems, to have more current status of coastal areas and to be able to quickly monitor changing conditions.

The Corps authority is very constrained because it is tied to Federally authorized construction projects. That is the reason that the Federal Emergency Management Agency paid for the emergency dunes in South Carolina following Hurricane Hugo. Subsequently, the Corps worked with the state of South Carolina in doing more permanent work on the dunes.

Another consideration is how the Corps transfers this technology and capability in usable form to other Federal agencies, state agencies, local agencies, and foreign countries. In my role with the US Subcommittee on the Decade for Natural Hazard Reduction, it is necessary to consider procedures that developing countries can use with their limited resources and limited technical expertise.

The Corps is in the process of evolving and developing an FRG under the R&D Program aimed at those items that are specific to emergency operations. Within the Corps' role in the earthquake response arena, the Corps is also going to become more involved in those FRGs tied to earthquake hazard reduction and earthquake mitigation efforts.

PUBLIC COMMENT

Mr. Edmond J. Preau, Jr., Louisiana Department of Transportation and Development, said his agency is part of the state task force on coastal restoration issues. They would like to support and encourage continued research in the field of coastal restoration, especially in the Louisiana area. They also would like to encourage the Corps of Engineers to use dredged material to the greatest extent possible to create new wetlands, not just when it is cost-effective.

Mr. Preau said that they would like to see the Corps designated as the clearinghouse agency for new ideas and techniques in the field of erosion control and other coastal restoration techniques. With the availability of funds, people are now coming out of the woodwork with new ideas and new technology. The state has neither the expertise nor the facilities to evaluate those things, but they feel that the Corps has those capabilities.

Mr. Preau said they would like to support continued research on storm surge modeling. He was impressed by the presentations at the meeting. He would like to request that the Corps be designated as the official Federal agency to determine storm surge elevations and the proper elevations for constructed protective works. There are a lot of different methods used, and he would like to see the Corps come up with one method for deriving the information, and be the official agency designated to furnish that information to the state and local parish governments.

Mr. Vernon Behrhorst, Executive Director of the Gulf Intercoastal Canal Association, said in his discussions with the Federal Emergency Management Agency (FEMA), the area which they are concerned with fronts the open gulf, or the open sea, and major bays yet to be defined. There is a major question about how far upriver effects extend. The FEMA is looking for a minimal coverage simply because they do not have the capacity to go up every bayou and stream, particularly where it relates to erosion along navigable waters, streams, and so forth farther back in the marshlands.

Mr. Robert S. Jones, parish engineer for the Terrebonne Parish Consolidated Government, said that predictive models for the erosion of Louisiana's coastal wetlands are needed, both with the barrier islands in place and with the barrier islands not existing. The reason is that the New Orleans District did a feasibility analysis of restoration or preservation of Louisiana's Grand Terre Island. Part of the benefits to be derived were the coastal wetlands that would be saved if the barrier island was preserved. The barrier islands were assumed to be 10-percent effective in saving coastal wetlands. It was determined that the costs outweighed the benefits to be derived. That analysis is used to justify nonaction by the Corps of Engineers on any of Louisiana's barrier islands. It is too important an issue or decision to be reached based on assumptions. An effort at predictive modeling needs to be made.

RESPONSE TO CHIEF'S CHARGE

Question No. 1: Is technology adequate for calculating inundation, waves, coastal erosion, and storm surge due to hurricanes?

The Board's response to this charge is posed in the context of that technology (hereafter - the Coastal Hurricane Modeling System) employed by the Corps of Engineers in assessing coastal impacts due to hurricanes. Of the four generic model components of this system (storm, surge, waves, and bathymetry), that of specifying realistic surface wind and, hence, wind stress fields for a given hurricane (by the storm or wind model) is perceived by the Board to be most critical. It is axiomatic that the accuracy of calculated storm-induced surge, waves, and associated inundation (for given bathymetry) can be no better than that of the driving winds and associated barometric pressure anomaly. Moreover, the estimated beach erosion is in turn critically dependent upon the wave and surge conditions created by the storm, as well as the proper parameterization of the sand transport processes. Such transport of sediments, of course, can be cross-shore due directly to waves and alongshore due to littoral currents created jointly by waves, arriving obliquely nearshore, and by direct action of the alongshore component of the wind during a landfalling hurricane.

The above overview highlights some points expanded upon below.

In its comparison study of several contemporary storm and surge models in 1980, the Committee on Tidal Hydraulics (1980) identified differences among wind-field models as a primary source of discrepancies in surge elevation estimates. This finding was re-emphasized in a 1983 report of the National Research Council (1985), in which a comparison of two wind-field models yielded significantly different results for common values of the three essential hurricane parameters (central pressure anomaly, radius to maximum wind, and forward translational speed). One of these wind models is that on which the standard project hurricane is based. The other is that employed in the National Weather Service's coastal surge model SPLASH (and its inundation version SLOSH). The planetary boundary layer wind model, currently being used by the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station, to force hurricane wave and surge model calculations, is perceived to be state-of-the-art relative to the technology embodied in the SPLASH and SLOSH models. Such technology is judged by the Board to remain, as in the early 1980's, only of fair quality for near coastal application. Improvements are needed in (a) parameterization of hurricane wind profiles (to allow multiple peaks), (b) feedback effects of waves on the drag coefficient for wind stress, and (c) nearshore modification of winds (including canopy effects due to vegetation and structures protruding through inundated regions). The canopy effect reduces the wind driving of waves and surge and also causes damping of waves within inundated areas. The technology for accounting for canopy influence exists but is not presently incorporated in flooding models except in an *ad hoc* manner.

Given the correct wind field, the technology for computation of surge and waves and their nearshore modification, as employed by the Corps, is considered by the Board to be good. In fact, CERC's modeling capability within the Wave Information Study (WIS) and its surge modeling (as exemplified by the WES Implicit Flooding Model (WIFM)) have long been considered at the forefront. There does exist, however, an aspect of surge calculations that is missing in most surge models, in spite of the fact that the technology exists. This concerns important feedback effects of waves on surge evolution. They are twofold: the first is the direct calculation of the *wave set-up* contribution to the nearshore surge and the shoreward inundation caused by wave radiation stress (National Research Council 1983); the second is the effect of surface waves in producing a significant *augmentation of bottom stress* caused by nonlinear wave/current interaction (National Research Council 1989). Wave setup in virtually all existing surge models is taken into account only indirectly (if at all), via the manner in which the model is calibrated (National Research Council 1983). Clearly, the direct calculation of the wave coupling effects on surge characteristics can and should be included in a proper Coastal Hurricane Modeling System. This is particularly important for inland flooding regions (where canopy effect is also of concern).

The technology required to deal meaningfully with beach profile changes remains very elusive, in spite of considerable efforts by sediment dynamicists (National Research Council 1989). Clearly, sediment transport model calibration is heavily dependent upon good prototype-scale data acquisition. The CERC's two-dimensional (2-D) SBEACH model, for estimating beach profile changes due to cross-shore sediment transport processes, appears to be a good start, and the Board looks forward to improvements which may accrue from the assimilation of the results of special experiments like SUPERTANK. However, the technology with regard to beach erosion due to hurricanes will remain less than adequate unless changes associated with alongshore transport of sediments are included in a fully three-dimensional (3-D) version of SBEACH. The Board considers that littoral transports caused by alongshore winds can be as significant as the cross-shore transports in a hurricane. While the Board notes that the CERC research and development (R&D) plans call for an upgrade of SBEACH from 2-D to 3-D, we feel that this should be assigned a higher priority.

Accordingly, the Board has the following recommendations related to this charge:

a. In order to improve wind simulations, an interagency collaborative study should be conducted to develop an upgrade of the wind model. The CERC and the National Weather Service of the National Oceanic and Atmospheric Administration would be the logical pair of agencies with the expertise to improve hurricane wind simulation.

b. Priority should be given to an upgrade of WIFM to include direct calculation of wave setup and wave-current interaction related to bottom stress.

c. The development of a 3-D beach profile change model should be moved up in priority in the R&D program.

d. The CERC should determine what additional laboratory and field data needs may be created as part of the implementation of each of these recommended model upgrades.

e. The CERC should also estimate what degree of improvement in modeling capability may accrue from the recommended model upgrades.

f. A long-term goal should be to have a truly coupled Coastal Hurricane Modeling System that allows feedback effects among all four components of the system.

<u>Question No. 2: What research and developemnt is needed to improve emergency operations during coastal flooding emergencies?</u>

This is a very specific charge related to one aspect of coastal flooding. The Board has three responses. The first response is that the potential exists for CERC to provide the various arms of the Federal government, state agencies, and local community groups with detailed information related to the potential for coastal flooding, coastal erosion, and structural damage impacts. Different groups may have different perspectives on the utility of the available tools that CERC can provide to improve planning for emergency operations during coastal flooding events. It would be a useful mechanism to utilize CERC as a service group for emergency planning, even prior to events. It remains to be determined if this information is actually needed by these groups to make appropriate decisions for protection of life and property.

The second response is a perceived need for more coordination and organization of research and development efforts among Federal agencies that best respond to the technical aspects of coastal flooding emergencies. For example, it is apparent the US Geological Survey (USGS) has been very active in evaluating coastal erosion from the point of view of wetlands lost. Was there cooperation with the Corps of Engineers and other agencies in these endeavors? The USGS may approach a problem in a different way than the Corps of Engineers approaches it. A melding together of these two might produce a better response to various emergencies or improved research and development regarding emergencies. Similarly, the Federal Emergency Management Agency (FEMA) has had a role in research relating to disaster response. Research and development relating to emergency response should be carried out as a cooperative effort with each agency aware of the efforts of others.

Third, additional research is needed to consider dynamic loading of expedient flood control structures. Initial efforts are described fairly well in CERC TR-88-4 (Markle and Taylor 1988), but there is additional need for full-scale controlled experiments to improve coastal flooding protective systems for rapid response.

The Board has the following recommendations related to this charge:

a. A series of separate workshops to determine interest in CERC tools available to improve planning for emergency operations should be convened for:

    1) State agencies.

    2) Local government and concerned community groups.

    3) Federal agencies such as the Corps of Engineers, FEMA, and the National Weather Service, among others.

Separate workshops are suggested due to the different agendas of the various groups involved.

b. There should be increased coordination (including R&D efforts) among Federal agencies that respond to technical aspects of coastal flooding emergencies.

c. Additional research should be conducted on the dynamic loading of expedient flood-control structures.

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BOARD RECOMMENDATIONS

BG Genega said that starting off the meeting with a review of the Coastal Engineering Research Board business provides good feedback, and is beneficial to the Board and the general audience. He noted that the Board appreciates receiving feedback on all its comments and questions. He said that the Board would like to formally note for the record its support of the proposed Coastal Inlet Research Program, and recommend that the Coastal Engineering Research Center (CERC) establish a technical advisory committee to play a role in the technical direction of that program. He also said that the Board recommends that CERC establish a formal seminar series in which all investigators would participate. They feel that this would provide an informal peer review.

Prof. Raichlen said it's very important for engineers and scientists at CERC to attend international meetings and visit comparable foreign laboratories, and for staff members of foreign laboratories to visit CERC. He thinks visits should involve enough time to have a significant interchange. He realizes there are very significant problems associated with this.

Prof. Dalrymple noted that tidal inlets had been discussed at the previous Board meeting, and their role in causing erosion of adjacent beaches. Since the topic of the next meeting will be dredging, he reiterated comments he made at the previous meeting. There is a strong correlation between inlets on sandy coasts and downdrift beach erosion since the inlets tend to trap sand moving past the inlet. Maintenance dredging of many of these inlets has resulted in the offshore disposal of tremendous quantities of beach quality sand which could have been used wisely as beach nourishment. He said, as his opinion, that the Corps of Engineers should determine the procedures by which this offshore disposal practice can be stopped. This would also apply to wetlands and wetlands creation with dredging in Louisiana.

Prof. Dalrymple said that an alternative to maintenance dredging of tidal inlets is establishment of sand bypass facilities, for either continuous or periodic bypassing. He noted that there was a very successful sand bypass plant at Indian River Inlet, Delaware, established by the Corps with state support. The Corps of Engineers should assess all tidal inlets which they maintain for the possible installation of sand bypass facilities. He noted that it would be beneficial to have a wave gage offshore of the Indian River Inlet plant. Not having a gage precludes being able to model what is going on in that vicinity.

Prof. Dalrymple noted that details of the upcoming SUPERTANK experiment had been presented. He asked for a progress report on that experiment at the next meeting.

BG Yankoupe said that having a format that includes presentations on issues of interest in the host Division provides unique opportunities to broaden the knowledge of the Board and meeting participants in areas that are directly and indirectly related to coastal engineering. He feels that the variety of agencies represented by presenters adds a great deal to the body of knowledge at the meeting.

BG Yankoupe referred to the presentations on coastal flooding emergencies. He urged participants to expand their knowledge in that area. He noted that we are making great strides in our ability to deal with these kinds of emergencies, and that there is not a large understanding, nationwide, of the role of the Federal government and its capabilities in that area.

CLOSING REMARKS

MG Williams said that the next meeting of the Board would be on 30 October to 1 November, and would be hosted by the New England Division of the Corps of Engineers. The theme will be dredging. The location will be in Boston.

The following meeting, in June 1992, will be hosted by the Corps' North Pacific Division. The tentative theme will be coastal structures. The October 1992 meeting will be hosted by the Corps' North Atlantic Division, with a theme of coastal data collection.

MG Williams said that, in closing the meeting, he would like to express thanks to the Board members and participants. He also expressed thanks to the Lower Mississippi Valley Division and the New Orleans District for hosting the meeting; to COL Gorski and his staff; to Ms. June Holly, the coordinator from the New Orleans District; to Ms. Susan McEnery, the receptionist and secretarial support; to Ralph Marchasse and Chuck Askings for audio support and Don Miller, the photographer and visual aids support; Roy Brown, Dennis Hoffman, and Felix Cretina for transportation support. He also expressed thanks to the WES staff: COL Larry Fulton, Dr. James Houston, Mr. Charles Calhoun, and Ms. Sharon Hanks, the administrative assistant to the Board; and to Ms. Dale Milford, the court reporter. The 54th Meeting of the Coastal Engineering Research Board was adjourned.

APPENDIX A

BIOGRAPHIES

H. LEE BUTLER

Mr. Butler serves as Chief, Research Division, Coastal Engineering Research Center (CERC), Waterways Experiment Station (WES). He directs a broad range of laboratory and field research studies/projects on forces and processes involved in beach erosion, hurricane action, sedimentation, and tidal hydraulics. He joined WES in 1973 as a team leader in the Wave Dynamics Division of the Hydraulics Laboratory directing numerical and analytical studies. When CERC moved to Vicksburg in 1983, Mr. Butler was selected to serve as Chief, Coastal Processes Branch. Prior to joining the Corps of Engineers, he was a senior scientist with the National Engineering Science Company and Tetra Tech, Inc., during the years 1964 through 1973. Both firms were located in Pasadena, CA. His responsibilities involved the development and application of numerical models in many subfields of civil engineering with emphasis in the field of hydrodynamics. Mr. Butler received a B.A. degree in physics and mathematics from the University of St. Thomas at Houston, TX, and an M.A. degree in mathematics from the University of North Carolina at Chapel Hill, NC. Mr. Butler is a member of the American Society of Civil Engineers, International Association for Hydraulic Research, and the American Geophysical Union. He is also a member of the Corps of Engineers Committee on Tidal Hydraulics. He received the WES Commander and Director Award and the US Army Research and Development Achievement Award in 1984 and has published numerous technical articles and reports.

GARY M. CAMPBELL

Mr. Campbell is currently assigned as the Acting Chief, Readiness Branch, Operations, Construction and Readiness Division, Civil Works Directorate, at the Headquarters, US Army Corps of Engineers (HQUSACE). He has been assigned to HQUSACE since 1980. Prior to his designation as Acting Chief of the Readiness Branch, Mr. Campbell has held a number of other positions and is also Chief of the Domestic Emergency Section. He previously worked in the Vicksburg District in Engineering, Water Control Management, and in Planning Flood Plain Management Services. At HQUSACE, Mr. Campbell has been involved in both the Natural Disaster and National Security Emergency Preparedness Programs, with responsibility for resources, funds, and manpower for the total Readiness Management Program from both military and Civil Works sources. He currently represents the Corps on the Interagency Hazard Mitigation Task Force, the National Hurricane Conference Coordinating Committee, the Federal Plan Annex Planning Leaders, and the Subcommittee for the US Decade of Natural Hazards Reduction. Mr. Campbell has a B.S. degree in civil engineering from Mississippi State University and is a registered professional engineer. He is a member of the American Society of Civil Engineers and the National Emergency Management Association.

THOMAS R. CAMPBELL

Mr. Campbell is Chief of the Report Review and Flood Plain Management Services Division, Directorate of Planning, Lower Mississippi Valley Division (LMVD). He has a B.S. degree in civil engineering and is a graduate of the Corps Planning Associates Program in Washington, DC. He is a registered civil engineer. Mr. Campbell was responsible for development of recreation facilities in the Mobile District for 4 years. He has been in LMVD for 24 years and has been responsible for conducting and reviewing comprehensive and specific studies in the Lower Mississippi Valley and the Upper Mississippi Valley and is a special advisor to the President of the Mississippi River Commission. Currently, Mr. Campbell is the coordinator of Corps participation in the Gulf of Mexico Program and serves in a part-time status on the staff of the Gulf of Mexico Program located at the Stennis Space Center.

JAMES E. CLAUSNER

Mr. Clausner is a hydraulic engineer with the Coastal Structures and Evaluation Branch at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). He joined CERC in 1981 after several years at the Naval Civil Engineering Laboratory where he was involved in design and testing of propellant embedment anchors and measuring submerged sediment properties. In his present position at WES, Mr. Clausner is responsible for research on sand bypassing and open water disposal site management and monitoring. Mr. Clausner received his B.S. (1974) and M.S. (1982) degrees in ocean engineering from the Florida Institute of Technology. Mr. Clausner is a registered professional engineer in the state of Mississippi.

ADRIAN J. COMBE

Mr. Combe graduated from Tulane University in June 1964 with a B.S. degree in civil engineering. Following graduation, he worked for a general contracting firm gaining experience in estimating, cost analysis, field engineering, construction, and pile driving. Mr. Combe has worked for the Corps of Engineers since 1967. He began his career in the Tidal Hydraulics Section of the New Orleans District. In 1970, he transferred to the Coastal Engineering Research Center in Washington, DC, where he worked in the Evaluation Branch of the Engineering Division. There, he worked on beach and nearshore processes and inlet dynamics. Later, Mr. Combe served for a year and a half as technical advisor to the Shoreline Erosion Advisory Panel which was formed by the Chief of Engineers to develop guidance on low-cost shore protection. In March 1978, he returned to the New Orleans District, where he became Chief of the Coastal Engineering Section, formerly the Tidal Hydraulics Section. Since that time, he has been responsible for beach erosion control, hurricane protection, flood control, and navigation in the coastal zone for the New Orleans District, which includes most of coastline of the state of Louisiana.

SALLY S. DAVENPORT

Ms. Davenport is director of the Coastal Division of the Texas General Land Office, which manages 4 million acres of submerged state-owned land in bays, rivers, and the Gulf of Mexico. Her duties include supervising assessments of proposed uses of state-owned land, development of land-use policies, and coordination with local, state, and Federal agencies. In 1990-1991, she coordinated an effort, mandated by the state legislature, to develop a coastal management plan for Texas state-owned coastal lands. Legislation implementing the recommendations of this plan is pending before the Texas Legislature. Previously, as a private consultant specializing in coastal issues, she prepared a publication analyzing the adequacy of existing coastal laws and programs with respect to current and future coastal resource management problems in Texas and testified before Congress on the potential impacts of the Coastal Barrier Resources Act in the state. She served for 3 years as administrator of programs for the Texas Coastal and Marine Council, coordinating the development of programs and publications having to do with natural hazards, floodplain management, and disaster response. She holds a B.A. degree from Texas Tech University and an M.S. degree in community and regional planning from the University of Texas.

JACK E. DAVIS

Mr. Davis is a research hydraulic engineer in the Coastal Structures and Evaluation Branch, Engineering Development Division at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station. His research and engineering studies are currently centered around shoreline erosion protection due to low-wave energy attack. He previously worked in the Research Division of CERC, primarily in the research and development of numerical wave models. Prior to transferring to CERC, Mr. Davis worked in the Hydraulic Structures Division of the Hydraulics Laboratory on studies related to reservoir water quality. Mr. Davis earned his B.S. degree from the University of Illinois at Urbana-Champaign in 1983 and his M.S. degree from the University of Texas at Austin in 1990. He is a member of the American Society of Civil Engineers.

JAMES B. EDMONSON

Mr. Edmonson is Executive Director of the South Central Planning and Development Commission, Thibodaux, LA, one of eight regional planning districts within the state of Louisiana. The District encompasses six parishes including: Assumption, Lafourche, St. Charles, St. James, St. John the Baptist, and Terrebonne. As Director of the Commission, he is responsible for advising elected officials on matters of regional importance and guides regional and economic development planning. Mr. Edmonson is a member of the Board of Directors of the American Shore and Beach Preservation Association and the Louisiana Coalition to Restore Coastal Louisiana. He has worked on the Gulf of Mexico Program, Coastal and Shoreline Erosion Subcommittee, for the past several years. Mr. Edmonson holds a Master of Arts degree from Western Illinois University in physical geography.

ROBERT P. FLETCHER, JR.

Mr. Fletcher is Chief, State and Local Planning and Response Division, Office of Civil Defense, State and Local Programs and Support (SLPS) Directorate, Headquarters, Federal Emergency Management Agency (FEMA). He is responsible for the policy, plans, operations, and all-hazard exercises for SLPS, and in particular, the Federal Response Plan under the Stafford Act. Prior to his assignment in FEMA, Mr. Fletcher held the position of Chief of Emergency Management for Headquarters, US Army Corps of Engineers (HQUSACE). He was responsible for the emergency programs of the Corps, including domestic emergencies, national security emergency preparedness, readiness exercises, training, evaluation and corrective action activities, and the operation of the Headquarters Emergency Operations Center. Mr. Fletcher held positions in HQUSACE in 1975, and previously worked in the Baltimore and Norfolk Districts. He is Chairman of the Emergency Management Committee of the National Capital Section of the American Society of Civil Engineers. He also represents FEMA on the Readiness Committee of the Society of American Military Engineers. Mr. Fletcher holds a B.S. degree in civil engineering from Virginia Military Institute and an MEA from George Washington University. He attended the John F. Kennedy School of Government, Harvard University, in National Security Programs, and is a registered professional engineer. Among his awards is the Department of the Army Decoration for Meritorious Civilian Service.

COL LARRY B. FULTON

COL Fulton became the 25th Commander and Director of the US Army Engineer Waterways Experiment Station (WES) in August 1989. Prior to his assignment at WES, he served as the Assistant Chief of Staff Engineer for the Southern European Task Force in Vicenza, Italy. COL Fulton has a B.S. degree in civil engineering from the University of Colorado and an M.S. degree in civil engineering from Oklahoma State University. He is also a graduate of the Industrial College of the Army Forces. Other command assignments include Company Commander, 70th and 84th Engineer Battalions, Vietnam; Commander, 4th Engineer Battalion, 4th Infantry Division (Mechanized), Fort Carson, CO; and Commander and District Engineer of the Far East District, Korea. His major staff assignments include Egypt Area Engineer, Middle East Division; Assistant Director of the Directorate of Engineering and Construction, Headquarters, Washington, DC; Deputy District Engineer, Omaha District; Instructor, Department of Tactics, Fort Leavenworth, KS; Resident Engineer, US Army Engineer Command, Europe; Augsburg, Germany; Executive Officer, 20th Engineer Battalion, Vietnam; and Platoon Leader and Operations Officer, 23rd Engineer Battalion, Germany.

DR. LINDA L. GLENBOSKI

Dr. Glenboski is the Environmental Resources Specialist in the Navigation Section, Projects Branch, Operations and Readiness Division, US Army Engineer District, New Orleans. She has worked as a botanist in the Regulatory Functions Branch in Operations and Readiness Division and in the Environmental Branch of Planning Division. Prior to joining the Corps of Engineers in 1981, Dr. Glenboski worked with the Department of the Air Force as a biologist. Dr. Glenboski received her B.S. degree in biology from Troy State University in 1969 and her Ph.D. degree in biology from the University of Alabama in 1975.

DR. NICHOLAS C. KRAUS

Dr. Kraus is a senior scientist in the Research Division at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station, working in the area of coastal sediment transport processes. He joined CERC in 1984 and previously was a senior engineer at the Nearshore Environment Research Center, Tokyo, Japan. Dr. Kraus is the Technical Manager of the Dredging Research Program area "Analysis of Dredged Materials Disposed in Open Waters," where he heads a group of five principal investigators involved with the mathematical prediction and field measurement of the movement of dredged material. In the Coastal Research Program, Dr. Kraus was co-developer of the shoreline change numerical simulation GENESIS and the storm-induced erosion model SBEACH. He is a member of the American Society of Civil Engineers (ASCE), currently serving as Chairman of the ASCE specialty technical conference Coastal Sediments '91, the American Geophysical Union, and the Society of Economic Paleontologists and Mineralogists. In 1987, Dr. Kraus received the US Army Research and Development Achievement Award.

J. PATRICK LANGAN

Mr. Langan has worked for the US Army Engineer District, Mobile, for the past 15 years. He is presently responsible for the Disposal Area Management practices for the navigation program. Mr. Langan served in an executive development assignment from July through December 1987 at the Dredging Division in Fort Belvoir, VA, and the Coastal Engineering Research Center, Waterways Experiment Station, Vicksburg, MS. He received his B.S. degree in civil engineering from Auburn University in 1963 and his M.S. degree in civil engineering from Purdue University in 1968.

E. CLARK McNAIR, JR.

Mr. McNair is Program Manager of the Dredging Research Program (DRP) at the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station (WES). The DRP is an integrated, multi-disciplinary research program that addresses the operational and managerial aspects of dredging. Several WES laboratories, as well as other Corps laboratories and Field Operating Activities, are actively involved in the DRP. New equipment and techniques will be identified, developed, or adapted for use by the Corps of Engineers for performing dredging operations more efficiently and economically. Mr. McNair earned a Bachelor's degree in civil engineering from Mississippi State University and a Master's degree in civil engineering from Texas A&M University. He is a member of the American Society of Civil Engineers, the Permanent International Association of Navigation Congresses, and the Western Dredging Association. He is a registered professional engineer in the state of Mississippi.

DR. MARTIN C. MILLER

Dr. Miller has been Chief of the Coastal Oceanography Branch at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station, since joining the Corps of Engineers in 1989. Prior to that time, he was a Senior Research Specialist with Exxon Production Research Company in Houston, TX. Dr. Miller's specialties are sediment transport and physical oceanography. He has designed and conducted several large research efforts in Alaska, California, and the North Sea for joint industry programs involved in offshore oil developments. A native of Ohio, Dr. Miller graduated from the US Coast Guard Academy in 1964. He obtained his Ph.D. degree in oceanography and ocean engineering from Oregon State University in 1979. Dr. Miller also holds graduate degrees in personnel administration from George Washington University in 1971 and geology from Wesleyan University in 1969. He is a member of the American Geophysical Union.

DR. SHEA PENLAND

Dr. Penland is a native of the Jacksonville beaches of northeast Florida and received his B.A. degree from Jacksonville University and his M.S. and Ph.D. degrees from Louisiana State University. Currently, Dr. Penland is the Acting Associate Director of the Louisiana Geological Survey (LGS). He has more than a decade of coastal research experience in the Gulf of Mexico, Gulf of Alaska, Beaufort Sea, North Sea, and Maritime Canada focusing on framework geology, coastal land loss, and environmental issues. Since 1982, he has worked at the LGS investigating the framework geology ad coastal processes of assessments for use as construction aggregate for coastal erosion control.

JOAN POPE

Ms. Pope is Chief of the Coastal Structures and Evaluation Branch at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES), and is responsible for overseeing the work of the Engineering Applications and Coastal Geology Units. This Branch includes civil, ocean, and coastal engineers, geologists, and oceanographers who are involved in evaluating and analyzing the application of research and development technology to coastal engineering problems. Ms. Pope is CERC's representative to the Wetlands Research Program Research Planning Group. Ms. Pope holds a B.S. degree from the State University of New York at Oneonta and an M.S. degree in geology from the University of Rhode Island. She started work at CERC in 1983 after working for approximately 10 years on coastal projects for the Buffalo District. Her research interests include development of design criteria for segmented breakwater systems, coordination of the development of a helicopter-mounted laser bathymetry system, and application of geologic and coastal processes to projects design, and WES's Study Manager for the Kings Bay Monitoring Program. Mr. Pope is WES's Study Manager for the Kings Bay Monitoring Program. She is a registered professional geologist in the state of Indiana.

DR. JOHN R. PRONI

Dr. Proni is the Director of the Ocean Acoustics Division at the Atlantic Oceanographic and Meteorological Laboratory of the National Oceanic and Atmospheric Administration (NOAA). He joined NOAA in 1972 as a senior research oceanographer. Previously, he was a senior scientist at the Bell Telephone Laboratories. In addition to his research in dredged material discharge, Dr. Proni is engaged, together with members of the research division he heads, in the study of wastewater outfall discharge in the coastal ocean. Dr. Proni has published numerous scientific papers mostly dealing with the use of acoustics for the study of materials discharged in lakes, estuaries, and the coastal ocean. He is member of the Acoustical Society of America. He has received numerous awards for his research efforts, including the Distinguished Authorship Award from the US Department of Commerce.

DR. SUSAN IVESTER REES

Dr. Rees is a native of South Carolina. She received undergraduate training in marine sciences at the College of Charleston and graduate training at the University of South Carolina. Since 1981, she has been affiliated in the US Army Corps of Engineers, Mobile District, serving as oceanographer in the Environment and Resources Branch, Planning and Environmental Division. Prior to 1981, Dr. Rees served on the faculty of the University of Alabama and was stationed at the Dauphin Island Sea Lab. Dr. Rees's duties include responsibility for the environmental aspects of civil works navigation and shore protection projects and military activities. She is ocean dredged material disposal coordinator, sediment specialist, and Project Manager of the Underwater Berm and Thin-Layer Disposal National Demonstration Programs. She also serves as the Corps of Engineers Project Manager for the US Navy Gulf Coast Strategic Homeporting. Other activities include: member, Advisory Council, University of South Alabama Coastal Research and Development Institute; associate editor, Northeast Gulf Science; member, Mississippi-Alabama Sea Grant Planning and Advisory Panel; reviewer, National Science Foundation; representative, Environmental Protection Agency Gulf of Mexico Program, and Federal co-chair, Freshwater Inflow Subcommittee. Dr. Rees has authored a number of publications and has received numerous honors including: US Army Corps of Engineers, Planning Excellence Award, 1990; Department of the Army Achievement Medal for Civilian Service, 1988; Mobile District Federal Woman of the Year, 1984; Who's Who in the South, 1983; Society of Sigma Xi, 1979; Outstanding Young Women of America, 1976; and Slocum-Lunz Foundation Pre-doctoral Fellowship, 1975.

THOMAS W. RICHARDSON

Mr. Richardson is Chief of the Engineering Development Division of the Coastal Engineering Research Center at the US Army Waterways Experiment Station. His organization's interests include measuring coastal processes, developing new field instruments and systems, and performing coastal engineering and geomorphic investigations. He holds a B.S. degree in civil engineering from The Citadel, an M.S. degree in civil/ocean engineering from the University of Miami, and a diploma in hydraulic engineering from the International Institute for Hydraulic and Environmental Engineering in Delft, The Netherlands.

T. JOHN ROWLAND

Mr. Rowland is a geologist with the Minerals Management Service (MMS), Office of Strategic and International Minerals, Herndon, VA. Since 1988, he has been actively involved with the Gulf of Mexico Task Force and activities related to various Atlantic continental shelf projects. From 1985 to 1988, he was a physical scientist with the US Bureau of Mines. From 1978 to 1985, he was a geologist with the US Geological Survey, Conservation Division, which evolved into MMS. From 1971 through 1973, Mr. Rowland was a geologist with the Coastal Engineering Research Center (CERC) in Fort Belvoir, VA. Principal activities with CERC focused on the Radioisotope Sand Tracing Program, sediment petrographic analysis and radiation safety. In 1977, Mr. Rowland completed an M.S. degree in geological oceanography from the Institute of Oceanography, Old Dominion University, Norfolk, VA.

ROBERT H. SCHROEDER, JR.

Mr. Schroeder currently serves as Chief of the Planning Division for the US Army Engineer District, New Orleans. As such, he directs the Corps' feasibility studies program in south Louisiana. He also directs the environmental and economic programs of the New Orleans District.

Mr. Schroeder has a B.S. degree in civil engineering from Tulane University and an M.S. degree in civil engineering from Louisiana State University. He has over 25 years experience in the planning and development of water resources projects.

MARK P. SKARBEK

Mr. Skarbek is a civil engineer in the Construction-Operations Division, Operations Branch, Navigation Section, US Army Engineer District, Jacksonville. He is the project engineer for Federal navigation projects in the south Florida area. Prior to working for the Corps of Engineers, Mr. Skarbek was a commissioned officer in the National Oceanic and Atmospheric Administration Commissioned Corps, assigned to the hydrographic research vessel *WHITING*. Mr. Skarbek was project manager for hydrographic and oceanographic operations aboard the *WHITING*, during which time he was presented with the Society of American Military Engineers' Kayro Award. He was formerly employed as a civil engineer for the Deputy Chief of Staff, Engineer, US Army Training and Doctrine Command. Mr. Skarbek is a registered professional engineer and received his B.S. degree from Pennsylvania State University in 1983.

FRANK E. STUBBS

Mr. Stubbs graduated from Mississippi State University in 1962 with a B.S. degree in civil engineering. He worked in the Little Rock and Vicksburg Districts, and currently works in the Lower Mississippi Valley Division. Mr. Stubbs began working in Emergency Management in 1973, and became Chief of the Emergency Management Division in 1980.

RUSSELL F. THERIOT

Mr. Theriot is a research biologist and Program Manager of the Wetlands Research Program. He has participated in and directed environmental research since employment with the US Army Engineer Waterways Experiment Station in

1976. Prior to this, he was an environmental specialist with the Florida Department of Natural Resources, Bureau of Aquatic Plants. He has an M.S. degree in botany and a B.S. degree in wildlife management from Northwestern State University in Louisiana and is presently pursuing his Ph.D. in aquatic and wetland ecology at the University of Florida. Mr. Theriot is a member of several professional societies, including the Society of Wetland Scientists. Additional duties include serving as the principal technical expert on the Corps negotiating team which developed and is revising the unified Federal Wetland Delineation Manual. He also serves on other national committees associated with wetland values, hydric soils, and hyrophytic vegetation.

DR. EDWARD F. THOMPSON

Dr. Thompson is a senior research hydraulic engineer in the Coastal Oceanography Branch, Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station. Since joining CERC in 1970, he has engaged in a wide range of research activities related to coastal waves, water levels, and meteorology. His degrees include a B.S. from the California Institute of Technology, an M.S. degree from the University of California at Berkeley, and D.Sc. from the George Washington University.

DR. C. LINWOOD VINCENT

Dr. Vincent is currently Senior Research Scientist (Coastal Hydrodynamics) for the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). His positions in the past include Chief, Coastal Branch, Wave Dynamics Division, Hydraulics Laboratory, WES; Chief, Coastal Oceanography Branch, Research Division, CERC, Fort Belvoir, VA; Senior Scientist, Research Division; and Program Manager, CERC, WES. Dr. Vincent's research interests include ocean wave mechanics, air-sea interaction, spectral wave modeling, wave climatology, and tidal inlet processes. Dr. Vincent has received an Army Research and Development Achievement Award, the American Society of Civil Engineers Walter L. Huber Prize for his wave research, and the Meritorious Civilian Service Award. He has written over 80 reports and papers. Dr. Vincent has a B.A. degree in mathematics and M.S. and Ph.D. degrees in environmental sciences (earth sciences) from the University of Virginia.

S. JEFFRESS (JEFF) WILLIAMS

Mr. Williams, a marine geologist specializing in coastal and inner continental shelf areas, has worked for over 20 years on marine research topics dealing with exploration of hard mineral resources, wetlands and coastal processes, and geologic origins and evolution of coastal margins and continental shelves. Mr. Williams has directed or participated in more than 50 geological field investigations along the Atlantic, Pacific, Gulf of Mexico, and the Great Lakes, as well as investigations in Great Britain. He has authored more than 100 technical and scientific papers and publications. Mr. Williams currently serves as a senior research staff geologist and Coordinator of the Coastal Geology Program with the US Geological Survey's Office of Energy and Marine Geology in Reston, VA. He previously held positions with the Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA; as a visiting scientist with the Institute of Oceanographic Sciences in Taunton, England; and with the Exxon Oil Company. His undergraduate and graduate degrees are in geology and oceanography from Allegheny College and Lehigh University.

APPENDIX B

STATUS OF ACTION ITEMS

CERB ACTION ITEMS AND STATUS

ACTION ITEM	PLACE AND DATE OF ACTION	RESPONSIBLE AGENT	ACTION AND STATUS
53-1. Take necessary action to have "Coastal Engineer" added to Federal Personnel Classification System.	Fort Lauderdale June 90	CEHR	Justification has been sent forward through HQUSACE to OPM.
53-2. Develop method for collecting and distributing information learned by Districts from their experiences with constructing coastal projects.	Fort Lauderdale June 90	CECW-E	Will be subject of future workshops. CETN's may be used.
53-3. Include a session on structure rehabilitation at the theme meeting on Coastal Structures in June 92, to be hosted by the North Pacific Division.	Fort Lauderdale June 1990	CERC	Session will be included.
53-4. Report on the Wetlands Research Program at the next meeting with emphasis on coastal aspects.	Fort Lauderdale June 90	EL	Reported at this meeting.
53-5. Report on the status of the Field Wave Gaging Program and results from the MCCP Program at a future meeting.	Fort Lauderdale June 90	CERC	Scheduled for June 93 meeting.
53-6. Review roles of other agencies involved with mapping sand resources, and invite appropriate representatives to a future meeting.	Fort Lauderdale June 90	CERC	On agenda for this meeting.
53-7. Determine feasibility of conducting a major O&M-funded research program on inlets.	Fort Lauderdale June 90	CERD-C	Determine feasibility of conducting a major O&M-funded research program on inlets.
53-8. Provide briefings on elements of the DRP at each meeting.	Fort Lauderdale June 90	CERC	Provide briefings on elements of the DRP at each meeting.
53-9. Provide at next meeting comparative data on costs of various sand bypassing systems.	Fort Lauderdale June 90	CERC	Included in Appendix C.

ACTION ITEM	PLACE AND DATE OF ACTION	RESPONSIBLE AGENT	ACTION AND STATUS
53-10. Determine roles of FEMA, the Corps, and other Federal agencies in collecting post-storm data and recommend how coordination between these agencies can be improved to provide a complete and consistent data set.	Fort Lauderdale June 90	CECW-E	Discussion on agenda for this meeting.
53-11. Provide copies of draft NED manual to civilian members for their review.	Fort Lauderdale June 90	CECW-P	Provide copies of draft NED manual to civilian members for their review.
50-3. Discuss with Army Research Office and Office of Naval Research the potential for basic research support for coastal engineers.	Virginia Beach Nov 88	CERD	Program announced as part of the Department of Defense University Research Initiative.

APPENDIX C

COSTS OF SAND BYPASS PROJECTS

COSTS OF SAND BYPASS PROJECTS

In response to action item 53-9 from the 53rd CERB meeting, Mr. James E. Clausner of the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station, prepared the following information on costs of sand bypass projects. Costs for a wide range of bypass options are presented in discussions of several Corps and one foreign project. Included are projects where large and medium-sized cutterhead dredges transfer sand from a protected sand trap, two examples of nearshore placement with a hopper dredge, and a project that uses direct pump-out of a hopper dredge. Also included are a very large and a medium-sized fixed plant bypass project using jet pumps. United States projects are listed by District.

The following table summarizes the bypassing costs for the most recent bypass operations. Most bypass operations using conventional dredges are scheduled once every 2 to 4 years. The bypass schedule column presents this interval between bypass episodes.

Table 1
Summary of Bypassing Costs

Project	Bypassed Amount cu yd	Bypass Schedule years	Unit Cost* $/cu yd	Mob/ Demob** $/cu yd	Total Unit Cost $/cu yd
Masonboro Inlet, NC	696,000	4	$2.30	$ .65	$2.95
Carolina Beach Inlet, NC	517,000	3	$1.72	$ .50	$2.22
Channel Islands, CA	1,500,000	2	$1.83	$ .42	$2.25
Perdido Pass, AL	320,000	2-3	$1.50	$ .31	$1.81
East Rockaway Inlet, NY	180,000	2	$3.30	$ .72	$4.02
Jones Inlet, NY	380,000	2	$6.00	$ .71	$6.71
Indian River Inlet, DE	116,000	Continuous	$2.50	$1.43	$3.93
Nerang River Entrance, Australia	440,000	Continuous	$ .83	$1.27	$2.10

* For fixed plants, the unit cost is the operating cost.
**For fixed plants, the mob/demob cost is the annualized cost of construction and equipment replacement.

Wilmington District (SAW): Information provided by Mr. J. Thomas Jarrett, Engineering Division, SAW, on 6 Sep 90.

Masonboro Inlet, NC - Masonboro Inlet is a jettied inlet, with a weir and deposition basin on the north side. In 1986, SAW bypassed 900,000 cu yd to Wrightsville Beach and backpassed 1,100,000 cu yd to Masonboro Island at a cost of $3 million. This operation was approximately 6 years worth of bypassing/backpassing. The operation was done with a 27- or 30-in. pipeline dredge with the material pumped 2 miles to the north and 2 to 3 miles to the south. The average unit cost was $1.50/cu yd. The FY 91 bypass/backpass operation will be 696,000 cu yd at a cost of $1,600,800 ($2.30/cu yd) with a mob/demob charge of $450,000 ($.65/cu yd), for a total cost of $2.95/cu yd.

If sufficient funds are available, SAW would bypass/backpass 1.2 million cu yd every 4 years (600,000 cu yd to Wrightsville Beach and 600,000 cu yd to Masonboro Island).

Carolina Beach Inlet, NC - Carolina Beach Inlet is a natural inlet north of the town of Carolina Beach. Between 1981 and 1988, SAW used the small capacity (400 cu yd), shallow-draft (7-ft loaded) hopper dredge Currituck for nearshore placement off Carolina Beach and the sidecaster dredge Merritt to bypass an annual average of 213,000 cu yd (135,000 cu yd Currituck and 78,000 cu yd Merritt) for a cost of $450,000 per year. This is an average of $2.11/cu yd. The SAW has also bypassed from the channel sediment trap using a large cutterhead dredge under contract. In 1991, SAW bypassed 517,000 cu yd from the sediment trap at a cost of $889,000 for a unit cost of $1.72/cu yd. The fee for mob/demob was $261,000, or $.50/cu yd. Planned bypassing frequency is every 3 years. Material is placed 1-2 miles south of the inlet.

Los Angeles District (SPL): Information proved by Mr. Arthur T. Shak, Engineering Division, SPL, on 30 Oct 90.

Channel Islands, CA - During 1991, SPL estimates they will bypass 1.5 million cu yd from the sand trap located behind the detached breakwater at Channel Islands Harbor, a distance of about 2 miles to the beach at Port Hueneme. The work will probably be accomplished by a 30-in. or larger cutterhead dredge under contract. The estimated cost is $2.25/cu yd ($1.83/cu yd for dredging and $663,000 mob/demob or $.42/cu yd). Bypassing is normally done once every 2 years.

Mobile District (SAM): Information provided by Mr. Wendall Mears, Operations Division, SAM, on 16 Apr 91.

Perdido Pass, AL - Perdido Pass is a jettied inlet with a weir section and deposition basin on the east side of the inlet. During the most recent bypass operation (Oct-Nov 89), a 24-in. cutterhead dredge (under contract) bypassed 320,000 cu yd from the deposition basin and entrance channel. Material was placed on the downdrift beach up to 1 mile from the inlet. The cost of the operation was $1.50/cu yd with an additional $100,000 for mob/demob, which equates to $.31/cu yd for a total bypassing unit cost of $1.81/cu yd. Bypassing is normally done every 2 to 3 years.

New York District (NAN): Information provided by Mr. Soon Lew, Operations Division, NAN, on 22 Apr 91.

East Rockaway Inlet and Jones Inlet, NY - East Rockaway Inlet and Jones Inlet are adjacent inlets on the southeast coast of Long Island. During the summer of 1990, both inlets were dredged under a single contract by the hopper dredge Atchafalaya.

East Rockaway Inlet was dredged first, with the 180,000 cu yd placed in a several-thousand-foot-long feeder berm 1 mile south of the inlet. Material was placed on the 16-ft contour. The cost of the dredging and placement operation was $3.30/cu yd. Mob/demob for the two projects was $400,000. Splitting the mob/demob charge based on the total yards for each project gives $129,000 to the East Rockaway Inlet project. Adding the $.72/cu yd mob/demob charge to the dredging cost gives a total cost of $4.02/cu yd.

The 380,000 cu yd removed from Jones Inlet was placed on Hempstead Beach, 1-2 miles from the inlet. The Atchafalaya was moored to a barge with a booster pump to transfer the material through 5,000 ft of pipeline to the beach. The unit cost was $6.00/cu yd with $.71/cu yd for mob/demob, giving a total unit price of $6.71/cu yd.

Philadelphia District (NAP): Information provided by Mr. Augustus T. Rambo, Engineering Division, NAP, on 16 Apr 91.

Indian River Inlet, DE - The fixed plant, jet pump system at Indian River Inlet, DE, began bypassing operations 30 Jan 91. Cost of construction (cost shared with the Federal government and the state of Delaware) was $1.7 million. The system was designed to bypass 100,000 cu yd per year. Sand mined from the fillet on the south side of the inlet is pumped across the inlet to nourish the beach on the north side and thus protect the coastal highway from undermining. A more detailed description of the project can be found in the 53rd CERB Proceedings.

During the first year of operation, the system bypassed approximately 116,000 cu yd. Estimated costs for the first year of operation, including amortizing major equipment repair and replacement, was $290,000 or $2.50/cu yd. Amortizing the $1.7 million first cost over 30 years at 9-percent interest gives an annual cost of $166,000 or $1.43/cu yd. Combining the first cost and annual cost gives a total of $456,000, or $3.93/cu yd.

Gold Coast Waterways Authority: Information provided by Mr. Russell Witt in February 1990.

Nerang River Entrance, Southport, Queensland, Australia - The Nerang River Entrance is a stabilized inlet located on the middle east coast of Australia. This is a unique inlet/bypass project. Both the stabilized inlet and bypass project were designed together, with the realization that sand bypassing was needed for the project's success. The project consists of a 1,600-ft-long pier from which 10 jet pumps are deployed, one every 100 ft over the pier's outer 1,000 ft. The project is designed to bypass 650,000 cu yd per year through a 14-in. pipeline under the inlet a distance of up to 1,700 ft from the inlet. The bypass system is computer controlled to allow unattended operation at night to take advantage of electricity rates that are one third of the day rate ($.05/kWh at night vs $.15/kWh during the day). The unattended operation is possible because the downdrift beach is uninhabited. A more detailed explanation of the project can be found in the 53rd CERB Proceedings.

Operating costs for 1989, when 440,000 cu yd were bypassed, were $.83/cu yd. If the $7.2 million first cost and major component replacement costs are amortized over a 30-year life at 9-percent interest, the cost per cubic yard increases to $2.10/cu yd, assuming 650,000 cu yd are bypassed annually.